ELECTRICAL ENGINEERING

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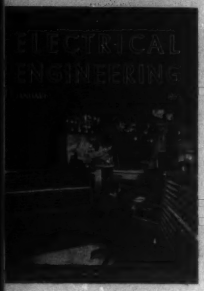

The Cover: The organ-like set-up is the new Izenour board which presets light cues and stores them in "memory boxes." This Izenour board at Studio 72 (New York) is twice the capacity of the one originally installed in CBS Television City, Hollywood, Calif., and includes refinements developed during use in West Coast productions.

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JANUARY 1955

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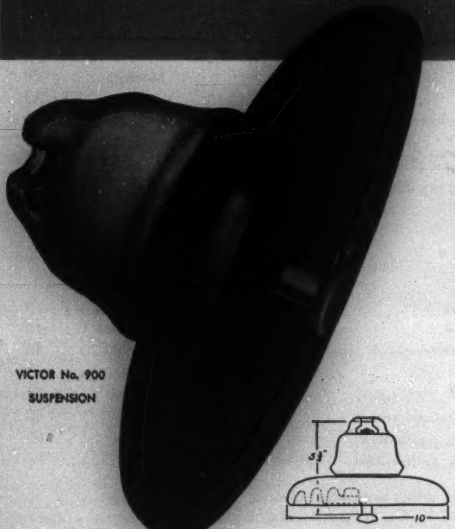

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Every VICTOR Suspension insulator is the result of sound design, superior craftsmanship and VICTOR *Purified* Porcelain—finest insulator porcelain ever made! That's why they have improved thermal resistance, better mechanical and electrical characteristics and greater resistance to impact. Thanks to VICTOR's unique "know-how," you just can't buy a better suspension!

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SPECIFICATIONS

Type.....ball socket	Leakage Distance.....11½"
60 cycle Dry Flashover.....80 KV	M and E Strength.....15,000 lbs.
60 cycle Wet Flashover.....50 KV	Impact Rating.....55 lbs.
Pos. Impulse Flashover*.....125 KV	RNI.....50 Microvolts
Neg. Impulse Flashover*.....130 KV	1000 KC at applied.....10 KV
Dry Arcing Distance.....7¾"	

*Crest KV. 1½ x 40 microsecond wave Critical Value

FEATURES

1. Higher mechanical strength
2. Greater resistance to thermal variations
3. Unequalled uniformity of mechanical and electrical values
4. Unequalled resistance to impact
5. Specially compounded cement for maximum strength
6. Caps and pins scientifically designed to withstand pull far above NEMA specifications
7. All metal parts hot-dipped galvanized for maximum resistance to weathering and corrosion
8. Special "cushion" coatings at all joining surfaces

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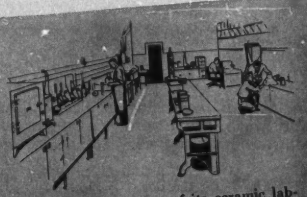

Victor has more than doubled the area of its ceramic laboratory. The enlarged laboratory affords Victor better, more modern facilities for testing raw materials, controlling quality of production and carrying on basic ceramic research. It was made necessary by Victor's expanding research program now under way.

SPECIFY *VICTOR*

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HIGHLIGHTS.....

Progress in Electrical Engineering. Twenty-five of the Institute's technical committees have reported on the major developments for 1954 in the fields of communication, power, industry, general applications, and science and electronics. This past year saw progress in the television network facilities, in the electronic computers, in the application of higher voltage distribution in metropolitan areas, and in developments as the solar battery and atomic battery. Many illustrations of the new developments, as well as discussions by the committees on the engineering progress, are given (*pp. 2–29*).

The Institute Adopts Deficit Budget. The chairman of the Finance Committee, C. S. Purnell, presents the figures for the present budget year, as recently approved by the Board of Directors. These figures should be of concern to each Institute member since, in the effort to maintain the present Institute services to the members, an unbalanced budget has resulted (*p. 1*).

Winter General Meeting. A list of the various activities is given for the AIEE Winter General Meeting to be held in New York, N. Y., January 31–February 4, 1955. Information is included for the general sessions, informal tea, hotel reservations, smoker, dinner-dance, inspection trips, theater tickets, ladies entertainment, and Eta Kappa Nu award dinner. The Edison Medal, the John Scott Medal, and the John Fritz Medal will be awarded (*p. 65–73*).

Attention Members. All members of the AIEE Institute are invited to submit material concerning their activities for publication in the AIEE Personalities columns of *Electrical Engineering*. A number of AIEE personalities are given for this month (*pp. 82–84*).

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Coal and Kilowatts. President Montieth, who is with an electrical manufacturing corporation, reviews the future of coal in the electrical utility industry. This is a timely subject, since there is the present development and construction of atomic-power generating plants, which could eventually displace other sources of energy. However, a bright future for coal can be assured if positive action is taken towards lower costs and more efficient utilization of coal's energy (*pp. 30–32*).

Nuclear Power Reactors. Three types of nuclear power reactors and the advantages of each type are described in this first part of a 2-section article. A discussion of the materials and their availability for use in reactors is given, as well as the various types of coolants used in the reactors. The government's and private industry's plans for reactor construction is told (*pp. 44–49*).

Ten Founding Fathers of Electrical Science. James Clark Maxwell, a Scotch physicist and electrical experimenter, had many interests in the physical sciences, which included special studies in the behavior of gases, the interchange of forms of energy, and of optics. He clarifies in his mathematical demonstrations the nature of an electromagnetic field, as related to light. His work later led to the discovery of electric waves and the mechanical pressure of light (*pp. 40–41*).

The Hazard of Sudden Darkness. The history of the development of the National Electrical Code is presented. The difficulties of reaching agreement on a single code are covered, as well as the manner in which minimum requirements for emergency lighting were incorporated into the Code (*pp. 33–38*).

A Point-Contact Transistor Test Set. This particular test set was designed to measure the important performance characteristics of point-contact transistors which will be used in large signal applications of the pulse and switching circuit type. The objective was to design a compact device that would be simple to use and which would utilize instruments readily available in any laboratory, such as oscilloscopes, pulse generators, vacuum tube voltmeters, etc. (*pp. 59–62*).

Conference on Transistor Circuits. The Science and Electronics Division of the AIEE will be one of the joint sponsors of the 2-day national conference on transistor circuits to be held in Philadelphia, Pa., February 17–18, 1955. Details of sessions to be held are given (*p. 74*).

Bimonthly Publications

The bimonthly publications, *Communication and Electronics, Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. The publications also are available to Student members at the annual subscription rate of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

Progress of Carrier and Microwave in Power System Operation. Power-line carrier systems have been greatly improved since first designed 25 years ago, and provide a means of communication which is, in many ways, more practical, economical, and reliable than other forms of communication. The history and development, and principles of operation and application are given in the article, as well as a discussion of the use of microwave radio to give a more flexible communication system (*pp. 49–52*).

Quality Screening for Audio-Frequency Impulse Noise and Microphonism. You can't test quality into a vacuum tube, but testing can produce a group of tubes for any one lot of improved average quality. The procedure and apparatus for such a test is given (*pp. 54–56*).

Western Computer Conference. A notice of the coming Western Computer Conference and Exhibit is given. This will be held in Los Angeles, Calif., March 1 to 3, 1955, under the joint sponsorship of AIEE, Institute of Radio Engineers, and the Association for Computing Machinery (*p. 76*).

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

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SPECIAL FEATURE: Provision is made for picking up the error signal directly at the load, compensating for the voltage drop in external wiring.

Model 2600

OUTPUT	VOLTS	CURRENT	REGULATION	RIPPLE
1	0-60	0-2 Amp.	5 Mv.	1 Mv.

Model 2650

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The Institute Adopts Deficit Budget

C. S. PURNELL
CHAIRMAN, FINANCE COMMITTEE

THE abridged budget statement for the year beginning October 1, 1954, was approved at the last meeting of the Board of Directors, after long consideration and study by the Finance Committee. It reflects an expected deficit of $105,900 after full extension of all present Institute services to its members. In the face of continuing intent to broaden and extend these services to an expanding membership, it also emphasizes the serious need to bring our financial operations into balance.

No business, of any nature, can long survive with this unbalance of income and outgo. If it should curtail its operations and impair the services to which its customers, owners, or members are entitled, the resulting loss in stature and value to individuals would be a serious blow to progress and development in its field.

Over the many years of inflationary influences, during which the Institute dues have remained stable, a close balance has been achieved through the most rigid attention to administrative expense and a continuing search for other means to augment income. Notable progress has been made in building up over-all income through higher advertising rates, registration fees at Institute meetings and technical conferences, and improvement in administrative efficiency. Appropriate Institute committees continue to study and evaluate their areas of activity to bring about greater services with less expense. However, the inevitable impact of rising costs of labor and material has made it most difficult if not impossible to accomplish further improvement.

BUDGET DATA
1954–55

Income	Estimated
Earnings on Investments of Reserve Capital Fund	$ 34,000
Membership Dues	580,300
(May 1, 1955, estimated 49,250; $11.80/member)	
Student Fees	30,000
(May 1, 1955 estimated 7,700; $3.90/student member)	
Entrance and Transfer Fees, Badges	26,500
Registration Fees	28,000
Institute Meetings and Technical Conferences	
Standards and Binders	10,000
Publications	521,000
	$1,229,800

Expenses	
Meetings—General and District	$ 49,145
Publications	733,450
Cost of paper, engraving, printing, binding, and mailing, plus salaries and general office expense	
Membership Badges	5,500
Sections	99,010
Basic allocations, per By-Law Sec. 49, to 105 Sections and 60 Subsections, plus share of Headquarter's salary	
Student Branches	12,710
Paper Prizes	9,750
Committees—All Technical and General	118,015
Joint Activities	63,910
United Engineering Trustees, Inc., Engineers Joint Council, Engineering Societies Library, etc.	
Traveling Expenses	74,150
District Executive Committees, Section Delegates, Branch Counsellors, District Student Conferences, Board of Directors, Vice-Presidents, etc.	
Administration	149,790
Salaries, plus general office expenses, legal service, etc.	
Pensions, Social Security, Insurance	20,270
Total expenses	$1,335,700
Total income	1,229,800
Excess of estimated expenses over estimated income	$ 105,900

The budget statement illustrates the major areas of income and expenses. For example, dues receipts are estimated at the present average of $11.80 per member on the expected membership during the budget year, allowing for nominal growth. Income from all publications reflects an expected 9 per cent improvement from higher advertising rates after adjustment for possible loss in accounts. In addition to these two principal sources of revenue, representing nearly 90 per cent of the total, all other sources have been estimated on the basis of nominal change.

Turning to the expense column, it is noted that Institute publications, the main artery of communication with members, take the largest share of income. In carrying out this primary purpose, members are offered without charge a great variety of publications which are the equivalent of $25 in cost if subscribed to by nonmembers. The estimate includes all costs for the preparation and distribution of *Electrical Engineering*, *Transactions*, bi-monthlies, preprints of technical and conference papers, the Year Book, and many miscellaneous special committee and technical conference publications.

Appropriations for other activities reflect the sober consideration of each component. Many of these are set by formulas in proportion to our membership in the United Engineering Trustees, Inc., the assessments for building (rent), the Engineering Societies Library, or the Engineers' Council for Professional Development. Others are determined by requirements of our By-Laws; for example, the allocations to Sections. Committee appropriations are arrived at from estimated requirements submitted by their chairmen after careful appraisal of needs to carry out the scope of their activities. Each receives close scrutiny before inclusion in the proposed budget. In a similar manner, all other expenses are examined to reduce them to the minimum consistent with the broad objectives of the Institute to provide its members with the maximum services.

An understanding of some of these fundamentals of budgeting should stimulate serious reflection on the Institute's need to maintain a proper and healthy fiscal balance. This can be achieved only by reconsideration of our dues structure. After consideration of this problem many times during the past 50 years, when members' dues were last changed, there now appears to be no further alternative to an increase from this source.

PROGRESS IN

During 1954—Reviewed by

Antenna on the right side of tower is the zig-zag type used for a booster TV station. This receiving antenna has a gain of 20.5 db

PROGRESS in electrical engineering has been widespread in 1954, as reported by 26 of the Institute's technical committees, covering its five broad divisions of activity.

In the communication field, television network facilities have been expanded from 49,000 to 67,000 channel miles this past year. Now 355 television stations are connected for network service of which 136 stations in 100 cities will be equipped for transmitting color telecasts. Over 5 million miles of telegraph channels are now used in private-line teletypewriter services. The Federal Communications Commission has authorized the operation of booster or satellite type of television retransmission, which will bring programs to hitherto inaccessible areas.

Improvements in computers have continued and their use has spread to industry as well as fields other than research. A television camera at the eyepiece of a microscope is the input to a computer which calculates blood count. The International Business Machines Corporation has announced an all-transistor computer.

This year saw progress in the battery field. An "atomic" battery was demonstrated by RCA which converts nuclear energy into electricity. Another development by the Bell Telephone Laboratories was the "solar" battery which turned light energy into electric energy. Progress was reported in the medical field with better means being provided for seeing and measuring the almost infinitesimal.

In the field of power, plans for the first press for the direct extrusion of aluminum sheath to the core of an insulated cable were announced. A major development is the application of higher voltage distribution in metropolitan areas, where a number of installations have been made with a system operating at 265/460 volts. During the year, 168 miles of double-circuit 330-kv line was placed in operation in Ohio with additional facilities under construction.

Communication

RADIO SYSTEMS

PLANS have been announced by the American Telephone and Telegraph and the International Telephone and Telegraph Companies in conjunction with the Cuban-American Telephone and Telegraph Company and the Cuban Telephone Company for the establishment of a broad-band multichannel telephone system using the recently discovered phenomenon of "beyond the horizon" radio transmission on frequencies heretofore considered useful primarily for line-of-sight distances. The proposed application, which was referred to in a petition to the Federal Communications Commission, would be for establishment of a system between southern Florida and Cuba to augment telephone facilities between Miami and Havana and for tests of television transmission on this route. Operation is proposed on frequencies in the range 680–890 mc using high-power transmitters with very large directive antennas to provide the necessary signal strengths for reliable transmission.

Facilities furnished by the American Telephone and Telegraph Company for network television broadcasting have been rapidly expanded during the past year and at the year's end totaled approximately 67,000 channel miles as compared to 49,000 at the beginning of 1954. In addition, a major portion of the network facilities have been re-engineered and re-equipped to carry color television signals. As of the end of 1954, it is expected that a total of 355 television broadcast stations will be connected for network service of which about 136 stations in 100 cities will be equipped for color. About 70 per cent of the network facilities are provided by microwave radio relay.

A new development was made during the year in the Loran system of navigation which operates in the 2-mc band giving daylight ranges of the order of 500 miles and nighttime ranges of about 1500 miles for guidance of ships and aircraft. This development consists of a new shipboard Loran receiver-indicator, which is used for measuring the time difference of signals from the land stations.

A surface search radar has been made available for small vessels using the 3-centimeter band. The indicator unit uses a 10-inch PPI tube and provides ranges of 1, 4, and 16 miles. The antenna unit has a horizontal beam width of 1.9 degrees and includes a 7-kw peak power magnetron, receiver, pre-amplifier, and other r-f components.

SWITCHING SYSTEMS

THE year 1954 has been rather unproductive of any outstanding new developments in the communication switching field; however, considerable development work has proceeded with regard to toll-dialing equipment, both for operators and subscribers. Manufacturers have developed new equipment for recording and routing dialed toll information and the Englewood subscriber dialing experiment is no longer considered an experiment but an established operating practice.

ENGINEERING

AIEE Technical Committees

One of the 75,000-watt incandescent lamps which was produced for Light's Diamond Jubilee compared with a replica of one of Edison's original lights

Attention has also been given to concentrater units, the Bell Telephone System having developed a concentrater for secretarial service in order to conserve conductors between buildings. There is also development work on rural concentrater unit by an independent company.

The teletypewriter switching system for fully automatic handling of military teletypewriter services reported last year has been simplified and the amount of equipment reduced by the maximum use of common equipment.

The Bell System has developed and placed in service in Washington, Detroit, New York, and several other cities, centralized automatic message accounting systems (CAMA) for customer-dialed multi-unit and toll calls. Billing data are recorded at a centralized crossbar tandem office to which the calls from a large number of local central offices are routed for recording purposes. The data are derived from the called number and from the number of the calling telephone which is obtained verbally from the customer by a cordless board operator. The recording is on a paper tape in the same form used in local automatic message accounting systems.

By the end of 1954, telephone customers in about twenty-five locations were able to dial their long-distance calls directly to the wanted line in a number of cities and locations ranging from Boston to San Francisco. Automatic accounting machinery in the central offices records the necessary billing data for each call by perforating digital information on paper tape. This tape is processed at an automatic message accounting center which produces a printed toll statement for each customer showing the date, charges, and destination of each toll call.

This long-distance dialing has found wide acceptance among telephone users and it is planned to eventually extend its use so that substantially all of the individual and two-party non-coin stations can dial any other station in the United States and Canada.

A new Traffic Usage Recorder has been designed which will supply more complete, accurate, and meaningful data in regard to the traffic loads on telephone equipment than was possible with older and less mechanized traffic measuring methods. The data supplied by the new recorder are important to traffic engineers who plan for optimum service with the available equipment and for better and faster service to customers.

During the past year, Western Electric Company started large scale production of the new wire spring general purpose relays developed by Bell Telephone Laboratories, and more than one million units were made.

As the telephone plant becomes more mechanized, relays are required to operate faster, last longer, and require less maintenance. Connections to relay terminals are being made in increasing numbers with wire-wrapping tools.

Variations of the wire spring general-purpose relay include wire spring relays having marginal operate and release characteristics, and slow release relays for special timing applications.

A new wire spring multicontact relay developed by Bell Telephone Laboratories is being manufactured by Western Electric Company. The basic design provides higher speed and longer life.

TELEGRAPH SYSTEMS

During the year there has been outstanding growth in private-line teletypewriter services as provided by both the telephone and telegraph companies. Private-line systems range from simple ones including merely two terminals to complex nationwide networks, some employing automatic switching devices to route automatically each message to its desired destination or destinations. Over 5,000,000 miles of telegraph channels are now used in these private-line services.

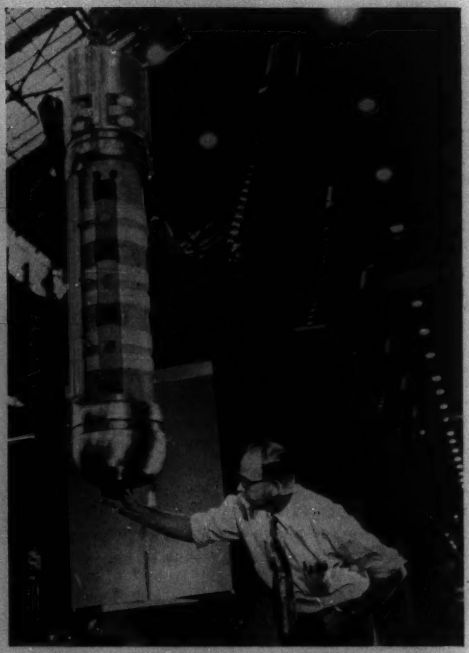
A program of submarine-cable repeater installations initiated by the Western Union Telegraph Co. in 1950 was substantially completed in 1954. It involves 11 repeaters of which 10 are located in 6 transatlantic cables between Newfoundland and the British Isles. As a result the traffic handling capacity of these transatlantic cables has been increased by 170 per cent.

A new multichannel frequency-shift carrier telegraph system using a unique method of diversity combining was developed for the Armed Forces long-haul high-frequency radio circuits. It provides 2 or 4 channels combining using frequency diversity or space diversity, or both.

In the Bell System additional channels were developed for the new 43-type frequency-shift carrier-telegraph system, some for use in the voice range and others for frequency bands otherwise unused above the voice range. Application of this system expanded greatly during the year. Service trials were made of Teletypesetter service at a speed of 600 words per minute over a voice circuit from New York to Boston with satisfactory results. The new 28-type teletypewriter employing a "type-box" for typing began to be delivered in substantial quantity for commercial uses. Previous deliveries had been for military use.

(continued on page 18)

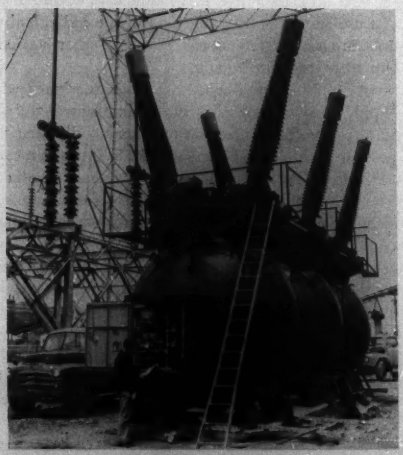
ENGINEERING DEVELOPMENTS



◀ New interrupter for 330-kv 25-million-kva Westinghouse circuit breaker is divided into four identical arc-quenching units. Each unit can be tested separately with available facilities, whereas single-break unit could never be tested at its full 25-million-kva rating. Each arc is drawn inside an interrupter block of fiber plates. Each block can be removed for its own inspection and also to leave a porthole through which the contacts can be inspected without disturbing their alignment. (Below) Unit-supported bus made by General Electric weighs 13½ per cent less than typical 3-phase sections and has single-insulator supports. It can withstand the high short-circuit currents of modern power systems and has a margin for future system growth. This bus design permits easier installation and maintenance than previous bus designs, and the single-supports reduce the possibility of insulation failure

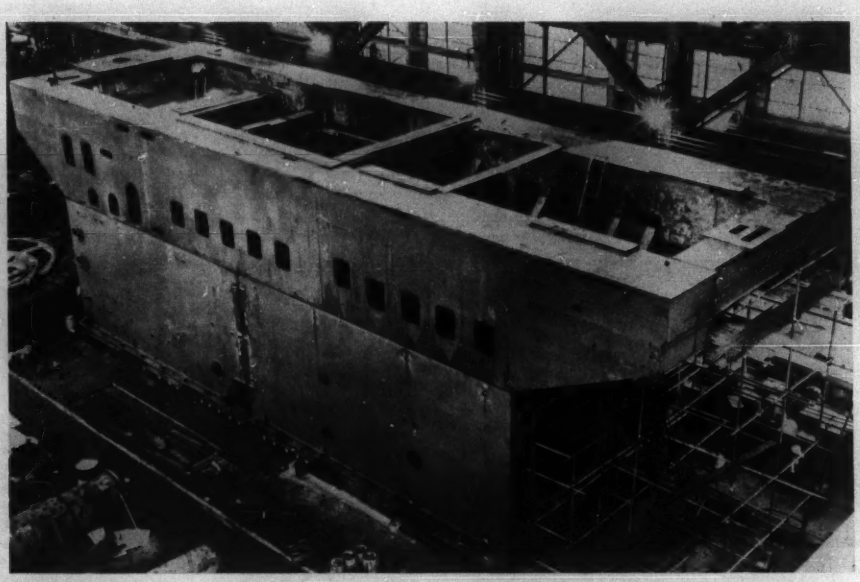
▼ 83-ton circuit breaker, the largest built by General Electric Company, can interrupt currents equivalent to 25 million kva on the nation's first 330,000-volt power transmission network. Installed at the Philip Sporn generating station, New Haven, W. Va., it is capable of interrupting the power in a twentieth of a second and restoring power so quickly that house lights hardly flicker

▲Largest self-cooled transformer ever built by the General Electric Company. Weighing 392,000 pounds, its self-cooled rating is 84,000 kva, but this can be increased to 140,000 kva by putting its 46 high-velocity cooling fans in operation. This unit will step up generated power from 18,000 to 115,000 volts for transmission purposes



A photographic record of some of the important electrical engineering achievements of the year

1954



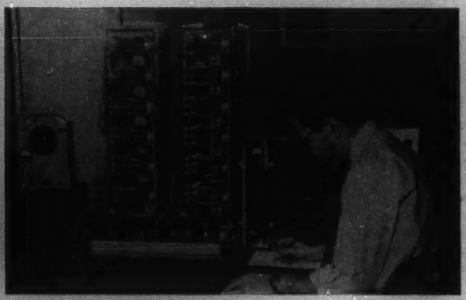
▲The giant condenser, shown here under construction at the South Philadelphia works of Westinghouse Electric Corporation, serves also as the foundation for the 125-megawatt turbine above it. The 80,000-sq-ft condenser is 60 ft long, 24½ ft wide, and 14 ft high. With its superstructure it weighs 1,365,000 pounds

▶ Bushing-type current transformers for a Westinghouse 330-kv breaker with a 25-million-kva interrupting rating. Up to 15 will be mounted on a 3-pole breaker, whereas 12 has been the highest number previously carried. Three of these transformers are used for revenue metering, and are unusually large to provide adequate cross section of the case to ensure the necessary accuracy. Each transformer is encased in Fosterite and contained in its own aluminum housing. This housing serves the purpose of protecting the transformer from damage during the process of assembly as well as in service

Research

◀The ballistocardiograph has been developed by the United States Air Research and Development Command in response to the need for a bloodless method of measuring heart-beat strength. This device is now used by the Command's scientists to evaluate the effect of partial pressure suits on the output of blood from the heart. Captain Carl Honig—of the Command's Wright Air Development Center's Aero Medical Laboratory in Dayton, Ohio—is shown here setting the ballistocardiograph into operation to measure the force and time course of the heartbeat of the sergeant reclining on the specially constructed light-weight bed. The very minute rebounds of the body, as the blood is ejected from the heart, are immediately measured and recorded in the form of a trace on the graph flowing from the machine shown on the left

▲Light-pulse generator used with special high-speed rotating mirror cameras in explosives research at the U. S. Naval Ordnance Laboratory, White Oak, Silver Spring, Md. It has a capacity of 200,000 light pulses per second and makes possible a calibration on film in intervals of 5 microseconds of the speeds of explosive phenomena. Demonstrating a laboratory model are Gypson H. Malone (left), electronic mechanic in the Detonation Division and Ralph D. Drosd, physicist

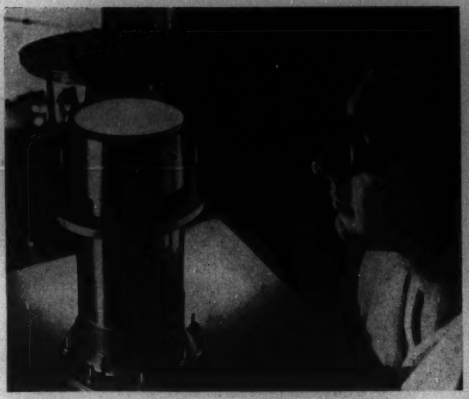


▲Remote strain-gauge switch developed by the U. S. Naval Ordnance Laboratory, White Oak, Silver Spring, Md., permits monitoring of up to 144 strain gauges using only 14 circuit wires. Since the stress analyses of submerged ordnance are complicated by the necessity of waterproofing the strain-gauge cables, the advantage of reducing the required number of cables from 576 to 14 is readily apparent. Sequence or random selecting permits repeated readings at critical areas

◀Magnetic recording drum for machine progress control is shown being adjusted by an engineer at the Armour Research Foundation of Illinois Institute of Technology. (Right) high-intensity sound chamber, developed by the Armour Research Foundation for the Wright Air Development Center, which can evaluate electronic components used in communication, aircraft guidance, and armament systems on jet- and rocket-driven aircraft and missiles. This sound box was designed to determine methods for improving reliability of air-borne electronic components by making them less vulnerable to vibration, acoustics, and shock disturbances

Courtesy Bell Telephone Laboratories, Inc.

▲Solar battery delivers power from sunlight at a rate of 50 watts per sq yd of surface. Specially prepared silicon strips about the size of razor blades are series-linked in the unit



Courtesy Westinghouse Research Laboratories

▲Flame study continues as ingenious techniques are employed to examine, point-by-point, a propane-air flame such as very special thermocouples which allow temperature measurements at 1-mm intervals

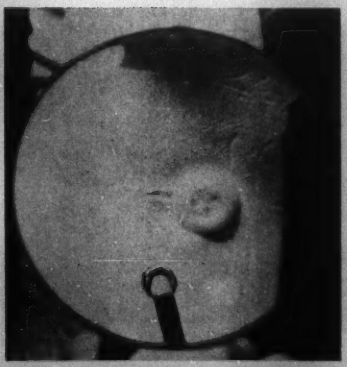
▼Pulse relaxation amplifier, an extremely sensitive magnetic amplifier operating from a pulse power supply, can be controlled by signals of 10^{-16} watt over a temperature range from −94 to +284 F. Several stages can be used to amplify a low-level signal to bring it to the microwatt level. From there, conventional amplistats boost the power to higher output levels. The pulse current can amplify signals as feeble as the change in room temperature caused by a lighted cigarette to control an air conditioner. Its principal component is shown: the reactor of two fine copper wires encircling a highly-sensitive magnetic core

Courtesy Radio Corporation of America

◀Magnified model of the two basic elements in an experimental atomic battery. The battery can convert atomic energy directly and simply into small but usable quantities of electric energy. Cylinder (right) has a thin radioactive coating on its face which is placed next to transistor-like wafer. Radiated electrons bombard wafer releasing more electrons.

▼Acoustic interferometer for the study of sound propagation under high pressures up to 30,000 psi. Apparatus is mounted in a pressurized cell contained in thermal jacket shown in foreground. The operator is shown manipulating the interferometer control which enters the cell through a pressure-tight rotating shaft

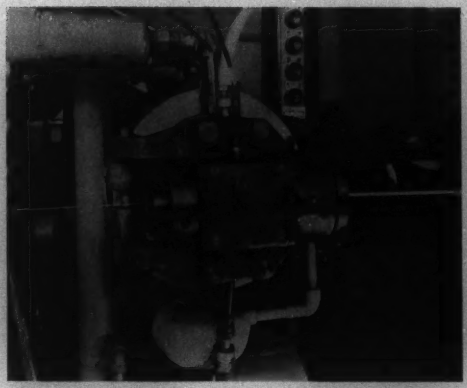
Courtesy General Electric Company

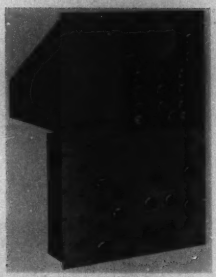


Courtesy U. S. Naval Ordnance Laboratory

Television
Black-and-White and Color

▲Combat TV employs hand-carried RCA Vidicon cameras for battlefield coverage. Here a TV cameraman covers part of a battle maneuver which can be viewed by the combat commander and his staff on the command post TV screen. The Signal Corps interim tactical TV system utilizes three ground Vidicon cameras, an airborne unit of two larger RCA cameras in an L-20 reconnaissance aircraft, and microwave relay and monitoring facilities. (Right) Wiring being extruded with Bakelite cellular polyethylene. This new cellular polyethylene has half the weight and a dielectric constant about one-half that of the regular polyethylene developed by the Bakelite Company. It will be especially useful in applications where weight savings in finished wire construction are required and where lower electric attenuation and line losses are necessary, especially at high frequencies. It makes commercially feasible the insulation of antenna lead-in wires for new uhf and vhf TV receivers. (Below) General Electric color TV is here used as a management tool—which will be one of its largest markets. The picture and sound are carried to the reception point by coaxial cables or microwave equipment. The small camera is easily portable. The screen shown is $4^1/_2$ by 6 ft and can be used for audiences of several hundred, but a large-screen projector also can be used with the system



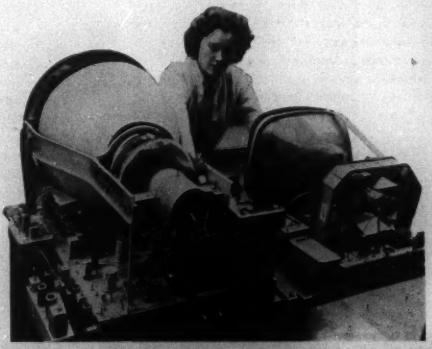


◀Vectorscope for color TV test and maintenance in both studio and transmitter. This Hazeltine Electronics Corporation apparatus accurately displays on an oscilloscope the amplitudes and phases of chrominance signals at 3.58 megacycles, thus permitting rapid checking of operating equipment. The Vectorscope also has an application as a tool in both research and development

▶Rear view of chassis and kinescope of the RCA 27-tube 21-inch color TV receiver. The wiring simplicity is evident in the chassis base shown in its normal vertical position

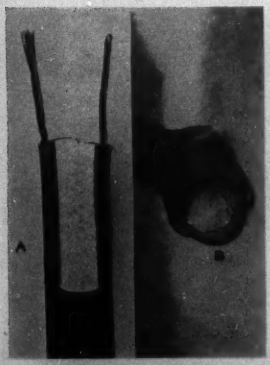
▲Lumitron-Magnalite lighting control console installed in NBC color TV studio in Brooklyn. This console controls the many large incandescent lamps required for the large-scale production of color TV programs. (Below) A. New 300-ohm line developed by Belden Manufacturing Company as a lead-in for uhf and vhf. Polyethylene core between the two wires is filled with tiny unconnected cells containing an inert gas. The cable's insulation is specifically designed to meet the problems of high-frequency transmission. The thick outer wall protects the cable against abrasion, water, weather, and mechanical damage. The bulge of insulation between wires, B, instead of the flat tape of conventional TV lead-ins, reduces the effects of moisture, soot, and dust on the wire's surface. The parallel conductors are annealed copper-covered steel strands with 49 per cent greater resistance to breaking than all-copper conductors. (Below right) Studio 72, CBS's new TV color theatre, New York. Its working stage area is over 5,000 sq. ft. The whole theatre is air conditioned and a new expanded Izenour board (see cover) electronically controls 500 stage-lighting fixtures

▲The newly equipped NBC color TV studio which utilizes the plant of the old Vitagraph Motion Picture Company in Brooklyn, N. Y. This supplements the facilities already existing at the Colonial Theatre and Radio City in Manhattan



▶Chassis of color (left) and black-and-white TV receivers compared. The color receiver requires more parts and much more time for factory adjustment and checking

Courtesy General Electric Company

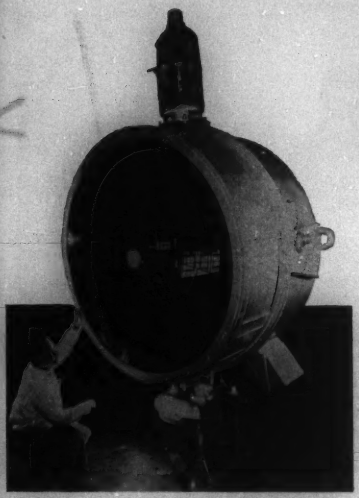


Facsimile and Telegraph

◀ New model facsimile telegraph instruments designed by the Western Union Telegraph Company for general office use automatically transmit (right) and record (left) lettersize communications twice as rapidly as older models

▶New compact facsimile telegraph instrument, known as the ticket-fax, produces Pullman reservation coupons at city ticket offices or suburban stations in a matter of seconds by transmission from a central bureau. This Western Union development will be utilized by railroads and airlines

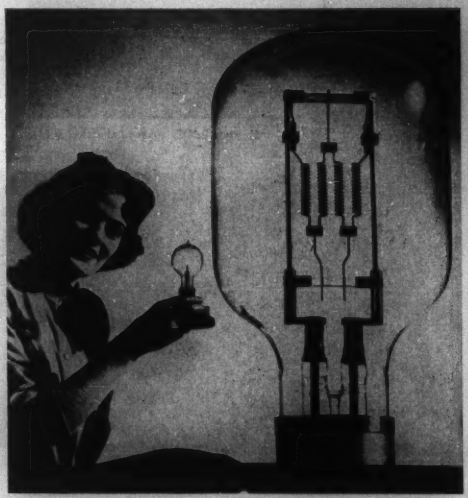
◀ New bulletin facsimile recorder, designed by the Western Union Telegraph Company for the U. S. Navy, continuously reproduces data, such as the weather map shown, on electrosensitive paper up to 18 inches wide. (Below left) multichannel carrier telegraph terminal equipment developed by Western Union for the Armed Services contributes greatly to the dependability of printing telegraph operation on long-haul short-wave radio circuits. It provides 16 frequency-shift carrier channels on a 3-kc voice frequency band; each channel is capable of teleprinter operation up to 100 words per minute. Channel receivers are of a dual type arranged for operation with 2-path frequency or space diversity radio transmission, and signals received over the two paths are combined by an improved method known as "ratio squaring." Included is multiplexing equipment to derive two 3-kc bands from each of the two 6-kc sidebands of the radio facility. (Below right) mechanization is now being employed in smaller Western Union offices. Shown here in this typical installation is equipment to resend telegrams, which arrive on perforated tapes, to tie-line customers without retyping them. Other copies are also made available for messenger delivery



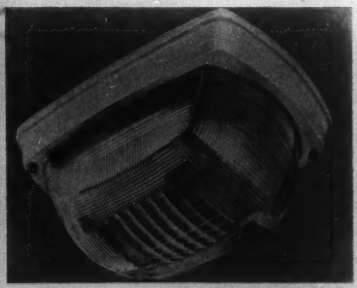
Lighting

Courtesy Westinghouse Electric Corporation

▲Giant searchlight, containing 2,500-watt short-arc mercury-vapor discharge lamp, develops 275,000,000 candlepower and throws a beam about 120 miles. (Upper right) revolutionary new infrared lamp, developed by General Electric, has a fused translucent quartz tube. It can light a cigarette as shown, yet is rugged enough to withstand a stream of water while heated to a cherry red, as shown, or even can be touched by a piece of ice without cracking. The lamp produces 100 watts per inch tube length, a higher concentration than has been possible until now. It is being made in 500- and 1,000-watt sizes for use on circuit voltages of 115–125 and 230–250, respectively. Its uses will include heating, cooking, baking, and drying applications. (Right) 75 years of electrical lighting are shown by the replica of Edison's first practical incandescent light bulb and the world's largest light bulb, built in connection with the electrical industry's observances of the 75th anniversary of the incandescent bulb. Weighing 50 pounds, this huge bulb is rated at 75,000 watts

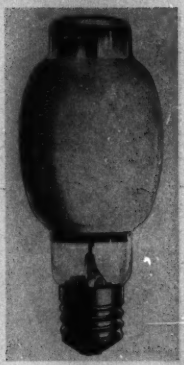


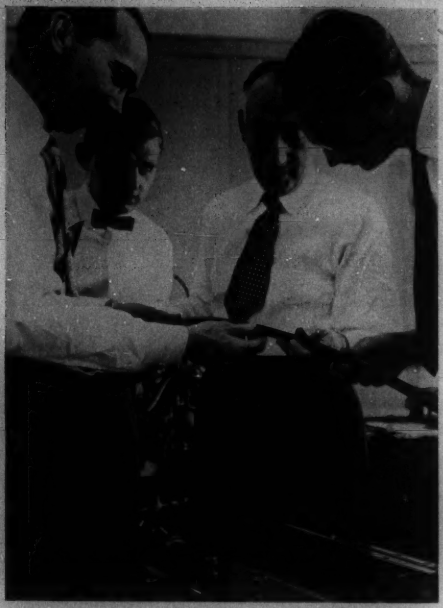
Courtesy General Electric Company



▲The Holophane C-284 luminaire, designed for corridor lighting, sends useful light not only to the floor directly but also to the ceiling and walls to be reflected for balanced illumination with high visibility. It also offers economies in installation and maintenance costs

▶250-watt color-corrected mercury-vapor Sylvania lamp is the first such lamp made available in the United States. Compared to incandescent light sources it offers several times the life and double the output for the same wattage. (Below) High light-output fluorescent General Electric lamp shown with holder produces 35 per cent more light than previous fluorescent source



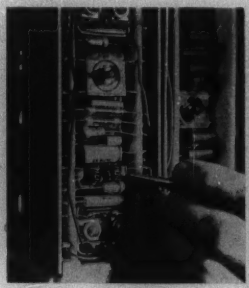


Courtesy Bell Telephone Laboratories, Inc.

▲First uhf portable communications set developed by Rome Air Development Center at Rome, N. Y., measures about 8 by 10 by $2^3/_4$ inches. Its weight is less than half that of the present set yet it has a much greater range. It was primarily designed for ground-to-air use. Airman at left demonstrates the front appearance of the set including the antennas on the combat helmet. (Left) research specialists examine perfect watertight joint in a section for the first transatlantic telephone cable. The transatlantic section, 2,000 nautical miles long and laid at depths up to 300 miles where pressures up to several tons per square inch are encountered, will provide 36 high-grade telephone circuits. Cable components were selected to provide at least 20 years of reliable service

Courtesy Radio Corporation of America

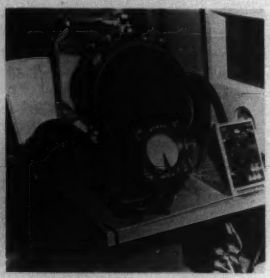
Courtesy Sylvania Electric Products, Inc.

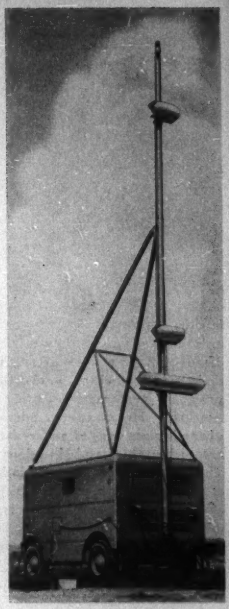


Courtesy Bell Telephone Laboratories, Inc.

(Above left) 21-inch color kinescope has nearly 22 per cent more viewing area than any other commercial color tube, yet costs the same as the 15-inch tube. Its unique curved mask helps improve the color brightness and fidelity. (Above center) stacked tube of revolutionary new design. It is stable under extreme temperatures, vibration, and shock. The ceramic envelope, the stacking feature, and use of ceramic, instead of mica spacers, aid in producing the tube's performance and reliability while enabling high mass production due to design simplicity. (Above right) two transistors are used in each oscillator subassembly for new rural telephone system tested at Americus, Ga. The over-all system will be reduced to about one tenth the size required when vacuum tubes are utilized. (Left) General Electric X-ray microscope which uses a beam of electrons striking a tungsten target to produce an enlarged shadow of a specimen which is placed inside the cone

Aviation





▶ Glideslope equipment for the improved low-approach system incorporates two beams for aligning aircraft with the landing strip developed for the U. S. Air Force by Federal Telecommunication Laboratories. It features a relatively broad and sharp landing beam and is compatable with existing installations in commercial and military aircraft. (Above left) the most powerful airborne radar yet built is carried by this new Lockheed long-range high-altitude reconnaissance scout. Antennas for this General Electric radar are mounted in radomes atop and below the fuselage. (Below left) major units of new APN-59 radar in early flight tests aboard Sperry research airplane proved compact enough to fit easily into single-passenger space. Left to right, rear, are shown the stabilizing gyroscope and transceiver; in front are the radar screen and synchronizer unit, and the master control panel which has many different uses

▶ Flight simulator room—bird's eye view—with the *F-89D* Flight Simulator in the foreground. The simulator's duplication capabilities include radar fire control. This Link Aviation Company's training device was produced in conjunction with Wright Air Development Center, Dayton, Ohio. (Below left) Volscan (air traffic control central), an automatic computation and control system for air traffic, which was developed by the U. S. Air Force Cambridge Research Center, Cambridge, Mass. The system directs large numbers of aircraft arriving at a base into an orderly landing flow, each aircraft is in this way delivered automatically to the entry of the final approach path at the precise instant that the landing system is ready. Volscan is able to sustain a 120-aircraft-per-hour landing rate—one aircraft every 30 seconds. (Below right) the Volscan Datac—the computer heart of the air traffic control central system

Transistors

▲New Beltone 3-transistor hearing aid can be hidden in a woman's hair or a man's necktie. Though 61 per cent smaller than their first transistor model, it provides clearer more lifelike hearing. Its magnetic microphone is more rugged and resistant to weather and humidity. The unit has ten different kinds of supersensitive receivers which emphasize or de-emphasize certain frequency patterns to fit high-, intermediate-, or low-tone deafness needs

▲Experimental General Electric radio receiver, small enough to be worn like a hearing aid, primarily for civil defense, is tuned to 1240 kilocycles. It weighs but 5 ounces and can be operated continuously for over a month without battery replacement as it uses germanium for the transistor and double-based diode

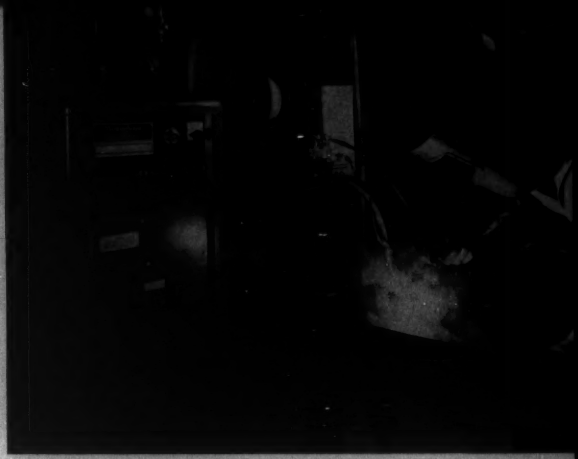
▲Self-contained solar-powered experimental transistorized radio transmitter shown with its designer, Edward Keonjian of the General Electric Electronics Laboratory. Selenium solar energy converters replace batteries. Light striking the selenium supplies the electric energy to operate the unit. Currently its range is about 100 ft but it can be improved by increasing the number of converters or using silicon or germanium instead of selenium

Courtesy General Electric Company

◀Three major steps of new transistor production method: Germanium ingot (upper left), was produced in 2 hours by the rate-growth method. This is sliced into thousands of tiny bars; each bar is 0.020 inch square by 0.1 inch long (lower left). The bar with leads attached becomes a transistor. Construction simplicity is seen in magnified view (right). A cap is added and the unit hermetically sealed in the final product

◀New Sylvania stable transistor demonstrated by E. Finley Carter, operations manager of Stanford Research Institute and former vice-president and technical director of Sylvania. Stabilized germanium is immune to surface moisture or deterioration as the crystal device ages. (Right) uhf transistor is tested for oscillation at the Bell Telephone Laboratories. Although this is an experimental transistor, oscillations up to 440 million cycles per second have been obtained. Frequencies generated by a transistor are picked up by the loop antenna on the wave meter held by Dr. J. M. Early, the uhf transistor's inventor

▲New high-speed automatic technique for the manufacture of transformer coils. Stacks of wafer coils are produced by rolling together wide sheets of very thin metal and similarly thin sheets of insulating paper. The roll is then sliced. Each slice or wafer can form the key element of an ordinary transformer and, in some cases such as for radio and TV frequencies, it may actually be the complete transformer. This Sylvania development not only can reduce substantially manufacturing costs, but would eliminate a potential bottleneck in electronic equipment production during a national emergency



▲Improved Westinghouse arc-welding process offers higher welding speeds, better quality welds, and lower operating costs. Field tests show this process has a 15- to 20-per-cent faster welding speed at a 25- to 50-per-cent lower cost than other manual and semiautomatic inert-gas methods. The key to the system is a new coated wire, but best results are obtained when it is used with newly designed light-weight exceptionally well-balanced gun, feed-wire control, and d-c arc welder. With this process it now is economically possible to weld mild steel

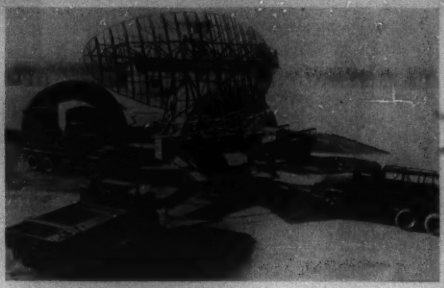
▶Portable vibration meter measures vibrations over a frequency range of 10 to 250 cps. The sensing element is a barium titanate accelerometer mounted in a preload spring cradle. (Below) Pittsburgh Steel's new tandem cold strip mill incorporates the most modern electric equipment. Rapid-response Westinghouse Magamps control the stand and reel drives. Indicating tensiometers on the first three stands of the mill give operators continuous indications of both tension and differential tension between the front and back of the strip, and an X ray and graphic meter indicate strip thickness. (Below right) gas shape-cutting machine is a medium area, rectilinear type with 4-torch capacity. The electronic tracer is the only fully automatic commercial tracer to use paper-cutout or pen-and-ink drawing templates

Courtesy General Electric Company

Courtesy Westinghouse Electric Corporation

Courtesy Air Reduction Sales Company

Radar



Courtesy U. S. Air Force

▲Radar set AN/MPS-7, which is a mobile radar search set shown at Rome Air Development Center, Rome, N. Y.

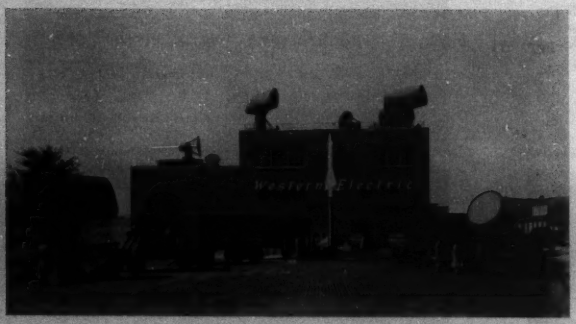
◀Radar set AN/MPS-8, which is a mobile height finder of the beaver-tail type shown at the U. S. Air Force's Rome Air Development Center, Rome, N. Y.

Courtesy Westinghouse Electric Corporation

◀Dime-sized gyroscope motor, probably the world's smallest, used on the moving antenna of aircraft fire-control radar. The "inside-outside" synchronous motor has a tiny wound stator; the rotor is also the inertia wheel of the gyroscope. The 2-phase 400-cycle motor operates on less than a volt per phase and revolves at 8,000 rpm. The gyroscope measures the angular movement of the antenna so computers can calculate firing data

Courtesy General Electric Company

▲3-cm pulse magnetron offers reliable nonpressurized operation up to 60,000 ft due to its evacuated waveguide. It is a forced-air-cooled fixed-frequency oscillator: 9 kw peak output; frequencies: 9345–9405 mc



▲NIKE, the U. S. Army's supersonic guided missile is here shown flanked by mobile equipment. The electronic controls, developed by Bell Telephone Laboratories and made by Western Electric, automatically guide the missile, made by Douglas Aircraft, from the ground to air targets. (Right) 4,000,000-watt klystron which was designed to power an advanced type of U. S. Air Force radar. The 8-foot giant, the prototype for a series of the military's most powerful microwave tubes, is here shown in the process of installation in a high-power radar transmitter at the Rome Air Development Center, Griffiss Air Force Base, Rome, N. Y.

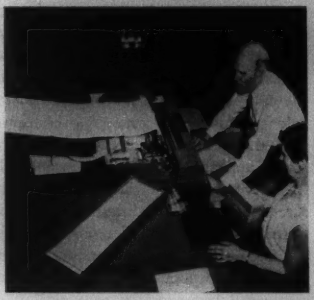
Computers

▲IBM's type-740 cathode-ray-tube output recorder. This close-up of the 21-inch tube shows an example of the way numbers and words based on the calculator's computations would appear. It can show computed data as graphs, geometrical figures, and engineering symbols. (Right) typical flight problems are put into electro-mechanical equipment simulating NIKE to provide essential flight data rapidly

Courtesy Bell Telephone Laboratories, Inc.

Courtesy International Business machines

▶IBM electronic computer being applied to power transformer design by the General Electric Company—1 hour can supply answers requiring 20–40 hours of manual calculation. Its use facilitates transformer deliveries, provides accurate design data on numerous alternatives for improved quality, and can supply quick answers to questions such as variation of hot-spot temperature under specified loading cycles and ambient air temperature



▲Toll recorder, part of toll collection and audit system. Reading clockwise on the "axial group indicator" are the axle and bumper patterns of a 4- followed by a 2-axle vehicle, both weighed. The 3-axle key has been depressed although the trailer truck being processed has dual rear wheels. This discrepancy caused the pattern to flash on the screen so the vehicle can be rechecked, the error corrected, and the vehicle reprocessed promptly. (Below) central computer group of Remington Rand Univac system. Left to right: supervisory control console, central computer, and bank of uniservos

▼The Naval Ordnance research calculator which has been developed by International Business Machines for the U. S. Bureau of Naval Ordnance. It is said to be the most powerful computing machine yet to be manufactured. It utilizes the decimal system in its operation and features the use of automatic floating-point arithmetic. Its over-all speed of operation is characterized by the addition of two decimal digits in a microsecond. Information is recorded on magnetic tape at a density of 500 digits per inch. The tape-handling speed is 140 inches per second

Courtesy Ezra Stroller

(*continued from page 3*)

Several new portable instruments were introduced for measurement of transmission of teletypewriter signals, their stability, and instantaneous distortions.

Further development on continuous-feed facsimile transmitters progressed to the point where two manufacturers announced such transmitters capable of handling copy up to 18 inches wide. Another new development is a delay distortion measuring instrument which facilitates lineup and equalization of long telephotograph or facsimile circuits.

TELEVISION AND AURAL BROADCASTING

Following the establishment of compatible standards for color television by the Federal Communications Commission in December, 1953, there was much activity in engineering, manufacture, installation, and operation in this new field. Extensive studio facilities were installed in New York and Hollywood. Numerous stations added equipment for the transmission of color programs received by network connection, and some installed more complete color equipment. Successful kinescope recording of color programs was practiced. Development continues on recording color television on magnetic tape with a reduction of tape speed from 30 to 20 feet per second, so that by the use of a 19-inch reel and other refinements it was possible to handle a 15-minute program on a single reel. During the fall of 1954 extensive programming of feature-type color productions began.

In the spring of the year color receivers of at least two makes appeared on the market, and sales in modest numbers were made. During the fall, larger sizes of color picture tubes, with maximum dimensions up to 21 inches, were announced and demonstrated. These were chiefly three-gun shadow-mask types, but another type, the single-gun strip-phosphor Lawrence Chromatron, gave promising results in laboratory designs.

This diagram illustrates how direct off-the-air pickups of regular TV broadcasts are rebroadcast as uhf signals to a valley town, where the original signals were unavailable

Television broadcasters have been limited in the coverage of their primary service areas by propagation losses due to hills, trees, and buildings. During 1954 at least four groups were doing research and development on a system of television retransmission designed to provide video reception in areas where good reception was formerly unavailable. The work on this booster, or satellite type of transmission, has proven highly successful and now the Federal Communications Commission has authorized the operation of such stations, provided they do not propose to originate any local programs.

Under the booster, or satellite, system of television a receiving antenna on a high tower picks up signals from a distant station. The signal is then amplified and retransmitted on the same, or on a different television channel so as to reach homes where the original signal could not be received.

WIRE COMMUNICATIONS SYSTEMS

One of the outstanding developments in communications systems announced during the past year is the proposed transatlantic cable and its extension from Newfoundland to the mainland of North America. The development and installation of this cable is a joint undertaking by the British Post Office, Canadian Overseas Telecommunications Corporation, and the Bell System. The cable is expected to be in operation by the end of 1956 and will link the telephone systems of the United Kingdom, Canada, and the United States by 35 telephone channels. An additional channel will be used for telegraph circuits between London and Montreal.

Of particular interest in the development are the submerged repeaters of the transatlantic link which use long-life electron tubes. These are contained in a flexible housing designed to facilitate installation and to withstand the tremendous pressure two miles below the surface of the ocean. The tubes are essentially equivalent to those used in the Havana-Key West cable, which has been in commercial operation for four years.

Power for the electron tubes will be fed over the cable conductors themselves from shore stations at each end of the submerged cable section, similar to the practice employed in coaxial cable systems in this country. In the longest section, a total driving voltage of 3,900 volts or higher will be required, equivalent to a potential of roughly 2000 volts between conductor and sheath at the shore stations. Carrier frequencies in this section for the telephone channels range from 20–164 kc in the two coaxial cables, one for each direction of transmission. Additional test channels and test frequencies are provided above and below this band. A total of 52 repeaters are to be used in each cable in this section.

It is expected that the telephone circuits will be operated at a via net loss of 0.5 db, which for such long circuits, means that echo control will be required. Studies of the methods of applying this to the transatlantic circuits, which must operate in tandem with other long circuits having echo control, are now under way.

General Applications

DOMESTIC AND COMMERCIAL APPLICATIONS

THE important heat pump development of the past year is the hermetically sealed refrigerant system with the trend toward elimination of the thermostatic expansion valves and increased reliability of refrigerant reversing valves and defrosting controls, allowing manufacturers to extend the product warranty towards 5 years, as is done with similar sized commercial equipment.

The primary objective is to obtain a practical, trouble-free device to provide satisfactory year-round comfort. Substantial accomplishments have been made toward increased reliability during the year and considerable development has been done to raise the over-all efficiency toward the theoretical maximum.

Domestic air conditioning (for homes, combined with oil- or gas-fired furnaces) has continued to grow rapidly with the total installed horsepower several times that for heat pumps. Water-cooled units are generally available up to 5 hp and some air-cooled units with nominal rating up to 5 or 7.5 hp.

The hermetic refrigeration systems with air-cooled systems have raised new problems on motor control and protection, requiring faster trip overloads, as well as lower cost control elements.

In the field of domestic appliances were more "trends" than anything radically new. The use of color on major appliances for complete surfaces, as well as trim, is one such. Another is the built-in range, with separate oven and surface units.

Portability of vacuum cleaners was increased by a shoulder-strap model, and the addition of large wheels to a cannister type. Steam ironing was extended to the travel iron. Rotisserie cookers come in larger units with special attachments. One completely new appliance is the electric skillet.

Farm usage of electricity is currently averaging over 5,000 kwh per year but some estimates put the 1964 figure above 12,000 kwh. Electricity is an important labor saver on the farm and farms are large load builders for utilities.

The most important and interesting development in this field is the electric generator mounted on a tractor for powering trailing machines, replacing complicated mechanical drives. In addition this offers mobile and transportable power, and temporary power during emergencies.

PRODUCTION AND APPLICATION OF LIGHT

AS symbols of the progress made in lamp manufacture from the time of Edison to this Light's Diamond Jubilee year, 75,000-watt incandescent lamps were produced and shown throughout the country. Lamp engineers created over 100 other new and still more useful sources.

New sealed-beam automobile headlights were announced. They put more light to the right for safer passing and have little upward stray light to glare back at the driver in rain, snow, and fog. A different kind of improvement was made in 28-volt airplane landing lamps. The filament design was changed to one with only the current-carrying lead-in supports. The filaments in the older design "wore out" by rubbing against their extra supports.

A lamp-design engineer points to the absence of upward stray light which makes this new all-glass sealed-beam automobile headlight safer for drivers

Some very old incandescent lamps were found to be causing television interference and some big studio lamps were found to be making enough noise that the sensitive television microphones could hear them. Engineers found out how to mute them and quiet lamps were made available during the year.

Eight-foot, 100-watt fluorescent lamps are now available and these high-output lamps produce a third more light than the previous output leaders, the 8-foot slimlines. By using the rapid-start principle of operation, no sacrifice had to be made in either the life or efficiency characteristics.

The year saw light output ratings raised for both straight mercury and those with fluorescent phosphors for improved color rendition. A "deluxe" inprovement in color was offered with lamps having ceramic filters as well as the phosphors. Some of the green and yellow mercury light is absorbed by these filter coatings to give a better spectral balance.

An improvement was made in reflector-type, color-improved mercury lamps. The metallic reflecting film was eliminated and the phosphor coating became effective three ways: 1) by adding missing color to the mercury spectrum; 2) by reflecting most of the light downward from the "inside" surface; and 3) by freely emitting the light generated on the "outside" surface.

The physics of light sources is a subject receiving much attention in Western Europe at this time. Progress is being made in the determination of operating characteristics of xenon lamps for color matching inasmuch as the xenon arc exhibits a spectroradiometric function over a large range of the visible spectrum very similar to that of global daylight.

High-pressure color-corrected mercury-vapor lamps are finding increased applications for exterior and interior lighting.

Large incandescent-lamp filaments were responsible for some of the noise picked up by sensitive microphones in TV studios. A technique was developed to quiet them

Some parts of Western Europe find it economical to operate sodium lamps for tunnel, street, bridge, and highway lighting. Belgium and The Netherlands use large numbers of these lamps for street lighting.

Totally enclosed hot-cathode fluorescent units in longitudinal and transverse formation are finding increased application for street lighting in some of the larger West German communities. Meanwhile dual light sources in which a short mercury-vapor arc is operated either in series or in parallel with a coiled tungsten filament, the combination self-contained within a glass enclosure, provide illumination for streets as well as approximate daylight characteristics for interior lighting and color matching.

Instrumentation has progressed to the point where high-accuracy, color-corrected, cosine-corrected light meters have been developed for more precise footcandle determinations. The shape of the amphitheater-like area surrounding the circular light-sensitive plate is determined from empirical data. Integrating spheres have been designed with no screen error since there is no screen, yet no direct light from the source can impinge upon the diffusely-transmitting window whose output is fed into a photocell.

In general, the louvered fixture has passed its peak acceptance and is being replaced by modern attractively styled and well-engineered plexiglas luminaires. End-to-end tube installations are now possible without tube overlapping in coves and luminaires to minimize decreased light output at tube ends due to absorption. Clear plastics serving as tube ends and pin supports, supplemented by similar plastic sockets, facilitate colinear end-to-end installations with practically uniform luminaire brightness.

Floodlighting as a tourist attraction is gaining momentum in Belgium, Flanders, and France. The lighting load increase is of little consequence, but the problem lends itself to the study of aesthetic appeal in attempting to accentuate the wealth of architectonic marvels of medieval times.

Lighting education has received a tremendous impulse in Western Germany through the co-operative effort of industry to subsidize research in leading higher institutes of technology, through organized training courses, and by releasing its best qualified men as regular lecturers in various phases of the lighting field at the higher institutes of technology offering courses in illumination.

Industry

CHEMICAL, ELECTROCHEMICAL, AND ELECTROTHERMAL APPLICATIONS

GERMANIUM rectifiers are delivering large direct currents in electrolytic service, especially producing hydrogen and oxygen. Involving several thousand amperes and d-c voltages up to 130, principal advantages are high efficiency (95 per cent) and small physical size. A unit rated 40,000 amperes, 24 volts for aluminum anodizing is now being installed.

The basic circuit used is the 6-phase double-way, or the 6-phase double-wye with interphase transformer. For protection against humidity or contamination, elements are immersed in an insulating and cooling liquid, or are hermetically sealed.

Control of the d-c output is by varying the a-c input by induction regulators or saturable reactors. Provision is made for high-speed fault protection and for polarizing electrolytic cells to avoid excessive inrush on energizing.

Magnetic amplifiers have been used successfully to meter and control currents of large electrolytic cell lines, where they solve two major problems:

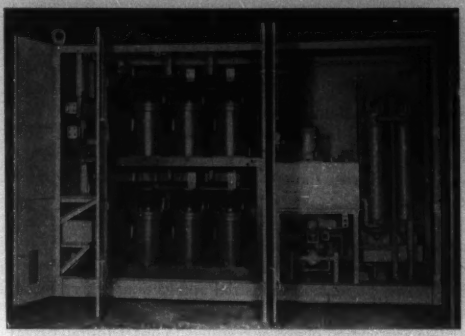
(1) Insulating meters and instruments from the d-c bus.
(2) Locating large cell line shunts and transductors to avoid costly busbar constructions and cell room corrosion.

In the form of transductors they meter large direct currents, amplify the output of conventional shunts, and pre-

Front view of a water-cooled germanium rectifier rated 65 volts, 4,000 amperes, 260 kw

sent particular advantages when totalizing the output of a number of converting units feeding a common cell line. Amplifiers used with shunts are small, and can be magnetically shielded so they may be placed near the shunts. Avoiding long and heavy leads, meters can be located in the conversion substation where conditions are favorable. Insulated for 1,000 volts, magnetic amplifiers remove bus potential from the cell line meters, lessen the danger of insulation failures, and reduce hazard to personnel.

Most recent developments include the use of magnetic amplifiers in the control of cathodic-protection rectifiers. Constant current output is frequently desired. The magnetic amplifier is providing wider range of control with more precision for such applications.



Metal-enclosed pumper ignitron rectifier

ELECTRIC WELDING

Arc Welding. Many of the recent developments in metal-electrode shielded arc welding were widely applied in production. Alternating and direct current with both straight and reverse polarity are now being utilized with these new techiques for all types of industrial weldments.

Transformer-rectifier d-c welders (selenium plate) have gained wide acceptance. Many improved control methods for such machines have been devised, and a rectifier welder has been introduced incorporating self-saturating magnetic amplifiers.

Static and dynamic volt-ampere characteristics of generator and transformer-rectifier types are being critically evaluated for merit in production welding applications. Equipment with a constant potential or even rising, rather than drooping, volt-ampere curve is increasingly used with process mechanization, permitting (in conjunction with a constant rate of filler metal feed) inherent, simplified regulation of arc length by current rather than auxiliary feedback loops, which vary the feed rate in response to arc voltage changes.

Carbon dioxide is being used satisfactorily as a low-cost substitute for argon or helium in some production applications of inert-gas metal-arc welding. One of these new methods combines the inert-gas metal-arc and shielded metal-arc processes by a tubular filler metal electrode containing solid flux, and inert-gas external shielding of the arc.

Magnetic flux supplied from a hopper and held to a bare-wire electrode by the field of the welding current to make a novel covered-wire electrode is being used for hard facing applications of shielded metal-arc welding. Several new covered wire electrodes containing iron powder in the coating, some suitable for limited all-position welding applications, have been applied successfully in production. The end of the electrode is moved along the joint in contact with the work and the arc is virtually hidden in a cone formed in the coating.

"Bare wire" electrodes lightly coated with an electron-emissive compound are being used to obtain spray-type metal transfer with straight polarity or a-c in inert-gas metal-arc welding, whereas the use of reverse polarity direct current was formerly required in such cases.

To overcome the bad effects of transformers of rectification in the arc with certain applications of inert-gas metal-arc welding with tungsten electrodes, batteries have successfully been used as a substitute for series capacitors to buck the d-c component of voltage drop in the arc. A comparatively weak spark at the critical instant in each cycle has been used in this type of welding to improve arc characteristics, apparently without causing communications interference.

Resistance Welding. The importance of fast electrode follow-up for maintaining pressure during nonferrous welding has received widespread recognition in industry. Low-friction and low-inertia welding heads are being utilized in conjunction with new methods of supplying energy to drive the head against the work. One of these methods consists of using the magnetic force of the welding current to supplement other means of mechanical clamping for the work. In general, there is increasingly widespread awareness in the industry that resistance welding requires the same quality of equipment and completeness of control as conventional machine tooling.

Schedules have been worked out to allow use of single-phase spot welding machines for certain welds in aluminum (helping to get the most out of existing equipment) with use of up and down slope currents. If dual force (forge pressure) is also available MIL Specifications can often be met. A 3-phase to low-frequency welder for heavy aluminum plates, with a secondary current of 300,000 amperes, has been built.

Temperature-controlled (thermostat-protected) ignitrons for longer tube life and conservation of water have been successfully applied on a wide scale.

Standardization and Safety. Progress has been very good in standardization of welding controls and equipment to provide long life, safety, and low maintenance cost for electric welding users. Particular attention has been devoted to studies of current which might pass through the human body at various voltages, frequencies, and circuit conditions, and how the operator may be protected from hazards.

ELECTRONIC POWER CONVERTER

An outstanding application of mercury and power rectifiers has been made by a large eastern railroad with an installation of 10 4,000-hp ignitron locomotives and 100, 400-hp multiple-unit cars powered by ignitron rectifiers The d-c motors in this equipment are capable of operating both from the 11,000-volt 25-cycle catenary over most of the division and from the 600-volt third rail at the New York terminal.

A new enclosed pumped rectifier has been announced, comprising a single compact assembly which contains the complete excitation and cooling equipment. This design has proven popular in industrial applications where space, safety, and low installation costs are of prime importance.

The application of power rectifiers to hot strip-mill drives in the steel industry has progressed to the point where individual rectifiers are used for each mill stand, eliminating a common d-c bus with its extremely high fault currents.

INDUSTRIAL CONTROL

A new standard to the industry in regard to brake adjustment and ease of replacement of parts has been offered in a new magnetically operated shoe brake built in complete compliance with the AIEE Standard No. 11. An individual adjustment is available for each brake shoe to establish the normal movement, which corresponds to the magnet gap gauged by an individual indicator. Torque may be readily adjusted by rotation of an adjusting nut.

All pivot pins have been eliminated. Marked reduction of bearing pressures has been effected by use of a revolutionary knuckle joint replacing pivot pins on the brake shoe levers. Lost motion in the usual pivot pin junction of field and armature members to the base has been eliminated by use of individual spring plates. Removability of each brake shoe, the wheel, or brake coil has been greatly simplified. The brake magnetic coil is encased in its own stainless steel enclosure, therefore, affording a weatherproof construction.

A newly developed Xatron power rectifier used in an adjustable-speed drive for the 30- to 50-hp range

Compact, completely sealed electronic circuits, which industrialize electronics for ruggedness and ease of maintenance, were developed. As many as fifteen separate electronic components are embedded in a polyester resin and further encased in a metal enclosure.

All components are protected from dirt, corrosive atmospheres, vibration, and shock. Rapid function-testing of the units assures that faults can be quickly located; screw-type terminals assure that any unit can be promptly replaced to minimize downtime in the event of a fault.

The first commercially available mercury-arc electronic adjustable-speed drive for the 30–50 hp range was produced. Developed by Reliance Electric and Engineering Company, this drive incorporates new single-anode Xatron rectifier tubes to fill the gap between small thyratron drives and high-power ignitron drives. The control units of the drive are physically smaller, far lighter in weight, and require much less floor space than their equivalent rotating conversion units. Controlled acceleration, voltage drop in the resistor compensation current limit, and peaking control are electrical features of the drive.

MINING AND METAL INDUSTRY

The most noteworthy developments in the mining and metal industry during 1954 were the increased use of magnetic amplifiers either alone or in combination with rotating amplifiers, and the trend toward higher and higher horsepowers on steel rolling-mill drives.

In the mining industry magnetic amplifiers found useful application on mine hoist and power shovel drive systems. At times they are used alone, and at times in combination with rotating exciters. They have given improved performance characteristics, particularly as regards response and dynamic performance which includes better current limit action with less overshoot and more accurate control of the regulated function such as speed or voltage.

Magnetic amplifiers are finding increasing use in the iron and steel industry also. Here again they may be used either alone or as a preamplifier ahead of a rotating amplifier. The number of applications has raised an imposing list and performance has been good. As would be expected from a device having no moving parts, maintenance has been low.

The trend to higher speed and more and more horsepower on hot- and cold-strip mills in the steel industry continues. For example, a five-stand tandem cold reduction mill for rolling tin-plate gauges has just been purchased by the Wierton Steel Company. This mill will have a total of 28,000 horsepower in drive units, and will have a top speed of about 7,000 feet per minute. A new hot-strip mill in the same plant will have 31,500 horsepower on the six-stand finishing mill. The trend in all industry is to use more horsepower per worker, and this trend shows an accelerated pace in the iron and steel industry.

Power

CARRIER CURRENT

The past year has seen increased application of power-line carrier to circuits which were formerly considered unsuitable, such as power cables and complex overhead circuits. This has been made possible by extensive tests to determine noise levels on transmission lines, and by computer studies followed up by field tests to confirm the calculations of carrier attenuation over paths involving more than one circuit. In addition, it is becoming more important to know the carrier frequency characteristics of ter-

minal apparatus so that their effect can be considered in the over-all transmission problem. However, in order that data from different sources can be compared, standards are being determined in a subcommittee for methods of measurement at carrier frequencies.

Another important factor in the increased use of power-line carrier has been the availability of frequency-shift type of carrier equipment for telegraphic functions. Because of the high sensitivity and noise-rejecting features of frequency-shift carrier, it is being applied with assurance to some high-noise, high-loss circuits and provides reliable channels for functions such as protective relaying and supervisory control. The channel performance can often be predicted now that there is more concrete data available on line noise and attenuation.

Microwave channels are also finding increased use, particularly in applications where power-line carrier is not practical. Because of the capability of a single microwave system in providing many telephone and telegraphic channels simultaneously, it is suited to use on extensive, well-integrated power systems and as a link between outlying stations and a centrally located dispatching point. Sub-carrier units have been developed, especially for microwave use, which provide a high degree of reliability against incorrect operation, even in the event of loss of signal or failure of a component part.

INSULATED CONDUCTORS

The use of aluminum for the conductor and the sheath of insulated cable has continued to receive attention. A progress report of a major investigation indicated the feasibility of replacing copper conductors with aluminum for high-voltage pipe-type cable applications insofar as dielectric strength, carrying capacity, cyclic movement in service, etc. are concerned and provided some promising approaches, but not necessarily the final answer, to the problem of the connectibility of aluminum. Plans for the procurement of the first press to be installed in the United States for the direct extrusion of aluminum sheath to the core of an insulated cable were announced.

A new high in underground transmission voltage for North America was achieved on the Canadian Kemano-Kitimat project with the installation of two 301-kv insulated cable circuits of the low-pressure oil-filled type. The cable for one of these installations was provided with an aluminum conductor and an aluminum sheath, the latter having been applied by the "draw-down" method.

Preliminary study and consideration has been given during the year to the possible need for laboratory and field trial research projects of insulated cable in the 400-kv range.

A single conductor "solid" type paper-lead submarine cable, 60 miles in length and operating on a 100-kv d-c system with water return, was placed in service during the year between the Swedish mainland and island of Gotland. Four single conductor "solid" type 69-kv paper-lead submarine cables, each about 30 miles in length, were installed during the summer of 1954 across the St. Lawrence River. Previous submarine installations at such voltages have not exceeded a fraction of these lengths. Prototype tests on other long submarine installations for even higher voltages were in progress throughout the year.

Favorable progress has been made during the year in the plans for the initiation of a comprehensive research project on the thermal resistivity of the soil.

An extensive study of the use and characteristics of limiters and fuses for secondary systems neared completion at the close of the year.

PROTECTIVE DEVICES

Another step in the improvement of protective characteristics of valve-type lightning arresters was completed in 1954. This development was a drop of about 20 per cent in discharge voltage for the generally available high-voltage arresters. The benefits obtained from this improvement in protective characteristics are: a greater margin between insulation level of the apparatus and the surge voltage as limited by the arrester; a greater permissible distance between arrester and apparatus to be protected before the overvoltage due to distance effects exceeds apparatus insulation strength; or full rating arresters may be applied on systems of questionable effectiveness of the neutral ground yet have the same margin of protection to reduced insulation level that was obtained previously with reduced rating arrester.

RELAYS

It was announced that the first all-electronic carrier relaying system was placed in service, providing faster operation, with less instrument transformer burden than has been attained with electromagnetic elements. The scheme includes electronic relay elements, a directional overcurrent relay for ground faults, and modified impedance relays for phase fault protection. Laboratory and field tests have proven the feasibility of using electronic relay elements, although it is expected that widespread replacement of conventional electromagnetic elements must await improvements in the reliability of electronic components, such as transistors. This development heralds the increased part that electronics will play in the field of power system protection.

This year saw the installation of new types of negative sequence relays for generator protection. These relays were specifically designed to match the thermal capabilities of generators when carrying unbalanced currents.

A new relay was produced, which provides protection for both the power system (against instability) and the generator (against thermal damage), because of either abnormally low excitation or complete loss of the generator field excitation. The relay provides a warning to the station operator when time is available for him to attempt corrective action, while also automatically tripping the machine when there is danger of system instability.

Directional comparison carrier relaying was installed for use with frequency-shift power-line carrier equipment. The functioning of the relay equipment is essentially the same as that employed with conventional carrier equipment. Because of the narrow-band characteristic of the frequency-shift equipment, which makes it desirable where a channel must be fitted into a crowded frequency spectrum, a slightly

An alternator and rectifier for truck refrigeration system undergoing a test on the bench

slower relay tripping speed is tolerated. The frequency-shift apparatus is capable of operating through about twice the decibel attenuation of the conventional carrier sets, making frequency-shift relaying particularly suitable for protection of high-voltage power cables.

ROTATING MACHINERY

In 1954 the development emphasis for rotating machines seems to have shifted to the specialty lines on one hand and to such basic matters as insulation testing on the other.

Extensive test programs in several laboratories have confirmed the preliminary work on functional testing of insulation systems which led to Tentative Standard AIEE No. 1*C*. These tests have shown that tests are reproducible within reasonable limits when equivalent systems are tested in different laboratories. They also show that systems which are known to be different by field experience show the same differences in the accelerated functional tests. Development of similar accelerated functional tests for machines using form-wound coils and for high-voltage machines was started.

A line of shovels and drag lines up to 10 yards capacity has been developed with all operating motions driven through electromagnetic couplings with electronic controls. Power up to 350 horsepower is controlled with less than 1 kw in the control circuits.

An electric drive for truck refrigeration systems consisting of an alternator driven by the truck engine, a rectifier, voltage regulator, and direct-current motor was field tested this year. Rated power is delivered at all engine speeds including idling. For standby service in the garage or at the loading dock the system can be plugged into any 120-volt a-c service with no auxiliary equipment.

For many years the maximum practical rating for shaded-pole motors was approximately 1/12 horsepower. About three years ago this top rating started to increase and this year several manufacturers listed shaded-pole motors rated 1/6 horsepower.

An induction motor for direct drive of the circulating fan in a hydrogen annealing furnace operating at 2,150 F was built in 1954. This is a new high temperature for this type of service.

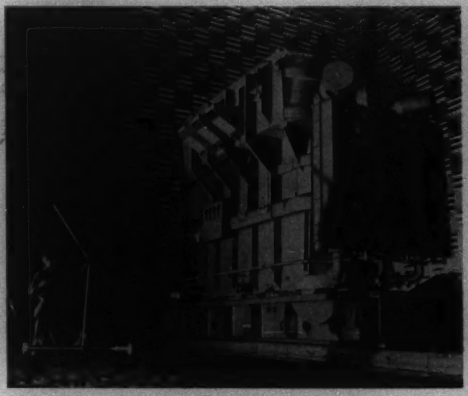
TRANSFORMERS

The transformer noise problem is being attacked from several angles. The new sound laboratory referred to in last year's report was dedicated in October.[1] Its anechoic chamber has the capacity for testing transformers rated 500,000 kva and higher. Complete frequency analyses will be performed on many units, and studies with acoustic transformer models will be employed both to predict the sound level in transformers being designed and to estimate the value of barriers and enclosures. A practical demonstration has been made of sound cancellation to minimize the noise of transformers already in service. Another manufacturer has found that the use of a sonic analyzer to study the frequency spectrum of transformer noise was of great help in noise reduction investigation.

A new manufacturing development involves the first application of a high-dielectric-strength gaseous insulation in high-voltage power transformers. The new units will be filled with sulphur hexafluoride gas. Transformers of this type will be lighter, safer, and quieter than liquid-filled units. Two transformers rated 2,000 kva, 69 kv, with gas-to-air heat exchangers, are now on the drawing board.

Several new molded-type current transformers have been developed. One is an epoxy resin type for low-voltage circuits; another is a polyester elastomer-encased unit for use on 600-volt lines, and a third is a silicon molded design in the 5,000-volt insulation class.

A potential transformer rated 220 kv line-to-ground, 381 kv line-to-line, was built for a switchgear development laboratory for use in the oscillographic recording of transient



A sound-level test being conducted on a 50,000-kva oil-cooled transformer in a sound laboratory by means of a microphone on the movable platform. Complete frequency analyses are made on many units. Such tests supply data which will aid in the reduction of transformer noise

A molded epoxy resin type indoor-outdoor current transformer rated 600 volts

voltage associated with high-voltage switching operations. It has insulation designed to withstand 1,550-kv full-wave and 1,785-kv chopped-wave impulse test. Many power transformers in the 330-kv range were under construction. Among these are 80,000-kva single-phase and 100,000-kva 3-phase units.

TRANSMISSION AND DISTRIBUTION

Progress continues in the development of extra-high-voltage transmission. During the year there were placed in actual operation 156 miles of double-circuit 330-kv line on the Ohio Valley Electric Corporation (OVEC) system, supplying the Atomic Energy Commission plant at Portsmouth, and 12 miles on the adjoining American Gas and Electric (A.G. and E.) system. An additional 235 miles now under construction will bring OVEC's 330-kv transmission to some 390 double-circuit miles; while approximately 500 miles of 330 kv, mostly single circuit on double-circuit towers, are authorized and in various stages of construction on the A. G. and E. system. Experience to date with radio influence under actual operating conditions has been on the whole satisfactory.

A major development is taking place in the application of higher distribution voltages to metropolitan areas. For heavy concentrated loads, the 120/208-volt system has its limitations and a number of significant installations have been made with a system operating at 265/460 volts (maximum voltage, 277/480 volts) using 440-volt 3-phase motors and 265-volt fluorescent lighting. This system generally consists of a number of transformers forming a spot network serving a large concentrated load. It is separate from the prevailing 120/208-volt system.

An interesting development has occurred in the application of shunt capacitors to low-voltage network systems. In recent years, the growth of small appliances and particularly of air-conditioning equipment has reduced the power factor on network systems to a degree that makes it economical to install low-voltage capacitors to release additional transformer kva. Capacitors have been developed rated 216 volts for direct connection to the secondary system. These are designed for installation in vaults and are made suitable for submersible operation with special corrosion-resistant cases. They are designed for an ambient temperature of 55 C. Groups of units up to 120 kvar are designed to clear a 30-inch diameter manhole.

Science and Electronics

BASIC SCIENCES

Marked advances have been made during 1954 in the fields of semiconductors, dielectrics, and magnetic materials. This is particularly true of semiconductors and of paramount importance is the development of silicon rectifiers capable of operating at high power levels up to 200 C, and of junction switching transistor devices for controlling appreciable amounts of power. Considerable progress also has been made in increasing the high-frequency response in junction transistors.

A "solar battery" and an "atomic battery" capable of converting sunlight and nuclear energy respectively directly into electricity have been announced. The efficiency of both of these devices, however, is rather low.

In the field of magnetic materials new developments in the magnetic ferrites continue to appear. Magnesium-manganese ferrites are now made with square hysteresis loops and are useful in computer circuits and magnetic memory devices. Other ferrites are used in wave guides and as new circuit elements. While some new materials have appeared in the field of dielectrics, perhaps more important is the continued emphasis on developing new information on the thermal behavior of insulating materials. Test methods have been developed for the thermal evaluation of insulation materials which are beginning to receive not only national but international attention through the International Electrotechnical Commission.

A number of recommendations concerning basic concepts in the electrical field have also been favorably received by the International Electrotechnical Commission. Considerable progress has been made in network analysis through the application of matrices, particularly in the treatment of multiterminal structures. Appreciable simplification has been effected in network synthesis through elimination of ideal transformers and reduction of networks to ladder structures. Other investigations in the circuit-theory field have brought out additional fundamental relationships between transient and steady-state responses.

ELECTRICAL TECHNIQUES IN MEDICINE AND BIOLOGY

Developments during 1954 in the field of medicine and biology were widespread. They cover the range from improved methods of detecting and measuring the small potentials developed by the heart to the design and installation of multimillion-volt sources of electrons and X-rays for therapy and research. Studies of the membrane potentials of a single heart cell provide the necessary information for the design of synthetic waveshapes which will result in better available information for use in the design of electrocardiographic equipment.

The linear accelerator powered by microwaves has been

made available for medical and biological research. Such equipment may be used to provide high-energy electron beams or very penetrating X-ray beams. One 50-mev electron beam installation has been completed and a 6-mev X-ray installation will be completed shortly.

Other significant developments in the area of medicine and biology are an X-ray microscope of high resolving power, improved electron microscopes, better image amplification of the fluoroscopic image, improved cine fluorography, progress in xerography (the dry development process for recording radiographic images), and improved instrumentation for measurement of ionizing radiations.

The use of radioisotopes is increasing rapidly. A number of large Cobalt 60 sources have been installed for cancer therapy, biological research, and instrument calibration. One of the isotopes of thulium has been used for studies as to its possible use for medical radiography. The AEC has recently announced plans for the construction of a plant to separate Cesium 137 for use in large sources for applications now limited to Cobalt 60. Although the radiation from Cesium 137 is of lower energy than that from Cobalt 60, the cesium isotope has a much longer half-life, 33 years versus 5.3 years.

ELECTRONICS

This year once more illustrates the fact that by the time any new electronic device is in use, its obsolescence in favor of a still newer device is just around the corner.

Thus this year's progress with ferroelectric ceramics (titanates) suggests that they may eventually obsolete the ferromagnetic ceramic devices that are just becoming useful for digital computer information storage. In turn, this ferromagnetic ceramic storage is just now overtaking the improved cathode ray (Williams tube) storage, which only recently proved its worth in competition with mercury delay-line storage. Ferromagnetic ceramics (ferrites) have appeared this year as nonreciprocal microwave components (the gyrator and the one-way transmission line) as well as in significant improvements of more conventional items, such as modulators, fast-switching units, and attenuators.

A low-noise microwave amplifier triode using metal-ceramic construction

The new insulating ceramics permit building smaller and higher-frequency electron tubes, with low-noise levels, threatening obsolescence of uhf tubes using glass-to-metal seals.

It appears likely that before long electrically tunable oscillators will supercede mechanically tunable oscillators in all radio-frequency ranges. In the uhf and microwave frequencies, this year's backward-beam traveling-wave oscillators, carcinotrons, and voltage tunable magnetrons bring this much closer, as do ferromagnetic and ferroelectric developments at somewhat lower frequencies. Microwave traveling-wave amplifier tubes have this year appeared in specific commercial equipments, and periodic focusing developments point toward major reductions in magnet size and weight in these and similar devices.

In television, the new experimental flat picture tube suggests a very radical departure. New "light-house," pencil-type, and series-heater-type tube designs are becoming available for input-end uhf home television receiver use.

As to color, there have been announced two promising new approaches to obtain more economical and stable color picture tubes for home receiver use.

Cold-cathode gas switching tubes announced this year indicate suitability for replacing voice-carrying relays in telephone central office switching systems; presumably before long either these tubes or semiconductor switching elements will make obsolete the outstanding crossbar switching development of 15 years or so ago. New cold-cathode and hot-cathode electron tubes combine circuit simplicity and reliability for counting and control at very high frequencies. Increased sizes of hot-cathode thyratrons have been put to use, as for example, in the control equipment for large ore-moving power shovels.

Consolidation and reduction to practice has characterized semiconductor advances this year. Thus "rate grown" germanium crystals make it possible to obtain many *n-p-n* zones per crystal, perhaps enough for several thousand transistors. Today silicon junction transistors, with their desirable temperature characteristics, are an experimental reality, as are a new form of tetrode transistors. Dependable transistors for use in the megacycle range have appeared. Also new is the surface barrier transistor.

This year's experimental demonstration of extreme stability of very-low-frequency transmission should soon have a great impact on navigation. Transatlantic frequency comparisons are now regularly made to about one part in 10^{10}, and the day-to-day variations in transmission time have been shown to have a magnitude of only a few microseconds.

Printed and etched circuitry is being brought into perfection, and many new light-weight, highly reliable, standard-form, and economical-to-operate equipments and components are making their debut, with especially great value militaristically. Mechanization of manufacture of electronic equipment, represented by Project Tinkertoy, has moved rapidly forward. Various types of "strip" transmission lines have been developed this year to replace the bulkier, more expensive microwave waveguide components. This year saw the acceptance of all-weather navigation by commercial airlines, based on military airborne radar developments.

There has been accelerated progress in use of automatic computers in business operations and manufacturing processes, involving the technique called automation, which is the engineering application of the concept of cybernetics.

Reliability of electronic equipment and electron tubes has, during 1954, become less of a prayer and more of a systematically approached engineering ideal, with far better knowledge than ever before as to what is and is not important, and what can and cannot be done in the present state of the art.

In the acoustical field, this year's titanates permit building sensitive microphones with geometric shapes as desired, thus removing the flat crystal shape limitation. Also, there have been introduced major improvements in auditorium acoustical engineering, including the use of delay techniques to equalize arrival of sound at the audience from various speakers. Acoustically driven earth-drilling tools capable of drilling deep holes that make right-angle turns have appeared, as have equipments for supersonic vibration of machine tools to improve cutting speeds and quality, and supersonic treatments of cleaning baths to complete the removal of grease and oil from metal parts being cleaned.

INSTRUMENTS AND MEASUREMENTS

Improved technology and new materials have enabled the field of measurements to be increased in scope and complexity and at the same time to meet the challenge of greater accuracy as demanded by associated fields of techniques and methodology.

Instruments. Indicating instruments which have been "ruggedized" and sealed are increasingly available for military use. Designed and manufactured to withstand the rigors of atmospheric changes from the tropics to the arctic and the shock of transportation by any means from ox cart to airplane, these instruments show an astonishing ability to continue performing their function under the most extreme conditions.

A new electromechanical recorder has been developed which provides a stable supply for the d-c potentiometer circuit without resorting to batteries or standard cells, thereby permitting operation from −55 to +55 C.

Significant achievement in the field of high-frequency measurement equipment has primarily been the integrating of new techniques into equipment. Electrometer-type instruments have reached the stage where they now can be used as industrial tools and are on the market from several manufacturers in the form of micromicroammeters, potential and insulation measuring devices. New frequency standard with frequency stability better than 1 part per billion was developed.

In the nuclear instrumentation field, improvements made in radiation-detection instruments increase their reliability and general usefulness. A number of advances have been made in scintillation-counter techniques in connection with counters for measuring small amounts of radiation from large sources and radiation from very high-energy particles. The newly developed bubble chamber, using a superheated liquid to obtain tracks in the form of lines of bubbles when ionizing radiation passes through the chamber, is attracting considerable attention.

Watthour Meters. Improvements in the load range of single-phase watthour meters are notable. Watthour meters with nominal rating of 15 amperes are capable of metering loads accurately up to 100 amperes. This can be visualized by noting that they operate with a high degree of accuracy from a starting load of 10 watts to a maximum capacity of 24,000 watts. Increased temperature rise due to the higher loads has necessitated new improvements in other parts of the watthour meters such as potential coils, yet the meters have maintained the same performance characteristics with the size and rating which permits them to utilize existing meter mounts.

Telemetering. Telemetering in industry and for military purposes has arrived at a position of primary importance in many fields where the modern trend is toward increased automaticity.

In the stationary telemetering field for measuring d-c quantities, a transmitter has been developed during the past year which replaces three different types previously offered for use. Six- to 27-cycle transmitting means is used and it co-ordinates the frequency-type telemeters available in the past for a-c quantity telemetering and can use the identical receiver and end device of this well established system.

Expansion of the impulse duration principle has been made to suit modern requirements for telemetering from up to 15 sources which can be miles apart on a time-multiplexed system, and in installations last year both individual recorders and multiple recorders were used successfully. The impulse-duration type is still indicating its worth since new devices by additional companies have been introduced in both a self-synchronized electromechanical version and also in an electronic version.

Foreign contributions in this field were viewed this year. One system of exceptional interest utilizing know-how in the missile telemetering field to produce a revolutionary stationary system is the Electro-Span. This employs a frequency code data transmission using carrier centered around 500 to 10,000 cycles. It provides 200 bits per second for a 2-kc bandwidth. All units are constructed on the plug-in building-block system and meet the standards of reliability and accuracy required by the industry. A second version uses a digital pulse code for lower-frequency response needs and provides 10 bits per second for a 30-cycle bandwidth. A tone signal control performs supervisory functions which may be on-off plus optional plug-in features.

A time-multiplexed Metameter telemeter system, showing the dispatcher's telemetering panel board. The incoming measurements are received over standard telephone lines from a distance of 125 miles

Complete telemetering and control electric systems have been made available in both this country and England. One equipment uses miniplaque miniature indicators which contain a proportional, integral, derivative and desired value adjustments and indicators showing the measured value and controller output. In one application, the recorders provide temperature, flow, pressure, Ph, and other measurements, while electrical integrators totalize the flow in product lines.

In the mobile field, an interesting proposal is concerned with MOUSE, a proposed satellite which would circle the earth at a moderate altitude for several days. New data could be obtained by using modern telemetering techniques.

Transistors. Transistors have inevitably been introduced into instrumentation, such as a transistorized oscillator. Similar techniques are being used in many fields including telemetering.

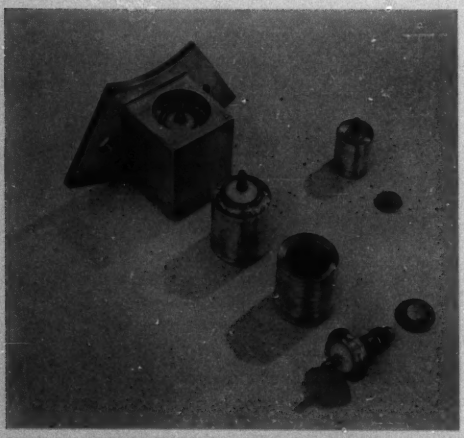
MAGNETIC AMPLIFIERS

Among the new magnetic amplifier circuit techniques which appeared in the 1954 literature were the disclosures of the pulse-relaxation magnetic amplifier, the biased-rectifier magnetic amplifier, magnetic amplifiers with fractional-cycle response time, and their associated frequency-multiplying power supplies, slaving circuits for keying the operation of additional reactors and rectifiers to half-wave reset-type magnetic amplifiers to give full-wave characteristics, and further clarification of circuit relationships with various passive- and active-type loads, including inductive, capacitive, and motor loads.

Among the principal material and component developments appearing on the 1954 magnetic amplifier horizon were silicon junction rectifiers, driven-transistor rectifiers, and early results of co-ordinated efforts to standardize core testing, matching, and grading techniques.

Silicon junction rectifiers when associated with magnetic components incorporating appropriate high-temperature materials afford a way of constructing magnetic amplifiers for operation in ambient temperatures approaching 400 F. This, of course, opens still further the field of commercial and military aircraft applications of magnetic amplifiers, which to some extent have been unable to compete fully in this field because of temperature limitations. The past year also revealed the use of driven transistors as virtually ideal rectifiers for magnetic amplifiers. Used in this manner, the transistor has been found to be a very stable, reliable circuit element consistent with the similar desirable characteristics of other magnetic-amplifier circuit elements. Among the devices developed using this type of circuitry are very low-voltage and low-power magnetic amplifiers, highly efficient static d-c to a-c converters, pulse-counting, and other pulse-type circuits, high-performance a-c input magnetic amplifiers, high-accuracy timing devices operating on digital principles and magnetic amplifiers to operate from d-c power sources.

The Materials Subcommittee of the AIEE Committee on Magnetic Amplifiers has been attempting to standardize magnetic core tests and grading techniques for cores employed in magnetic amplifiers. The past year saw the first results of their efforts, which promise to lead to practical commercial specifications in this area. The year 1954 was characterized by general broadening of the area of application of magnetic amplifiers in various types of products. They were applied in connection with central station generator voltage regulators, telemetering of high voltages and currents in large rectifier installations, pile and electric power controls on nuclear reactors, marine bearing-temperature monitoring equipment, and further in connection with transistors in servo and generator voltage regulator applications. Among the most interesting applications in this latter category are those in which transistors are used as nonlinear circuit elements and amplifiers with magnetic amplifiers as power stages. Appearances indicate that compatibility is excellent and that the combined characteristics will afford many opportunities for new control devices and systems.



A silicon rectifier for a-c aircraft generator

METALLIC RECTIFIERS

One of the more important limitations of selenium rectifiers is that the output current rating must be reduced as the room temperature is increased. A substantial reduction is needed for operating temperatures over 140 F. The development of a selenium cell that can be operated without a reduction in current rating with temperatures as high as 212 F has been announced.

The capacity of rectifiers using the germanium rectifying cells has been increased to 260 kw. A 65-volt 4000-ampere water-cooled rectifier has been made available. This rectifier complete with step-down transformers and fuse protection is enclosed in a sheet-metal cabinet.

A new type of a-c generator for aircraft has been developed. The key component in this generator is a set of six silicon rectifying cells fastened to the shaft between the a-c exciter and the main generator rotor. The rectifier has been designed to supply field excitation for a 40-kva 3-phase 120/208-volt generator. Since the rectifiers rotate

with the shaft, there is no necessity for brushes or slip rings. The problems associated with brushes at high altitude are well known and have been eliminated by this development. This new generator utilizes oil at 150 C as a cooling medium. The silicon rectifying cells each deliver one-half kilowatt of d-c power to the field winding while being subjected to 180 C ambient temperature and a centrifugal acceleration of 10,000 g.

As a culmination of years of research work on the preparation of *p-n* junctions by diffusing impurities into the surface of silicon, wafers have made successful high-power rectifiers. These broad area rectifying cells can convert very large amounts of alternating current to direct current. An important feature of these is that they can operate at much higher temperatures than other crystal rectifiers now in use.

One of a family of six 3-resonator tunable klystrons used to provide 12 kw in TV service over the 470-890-mc band

NUCLEONICS

THE Atomic Energy Act of 1954 became a law with President Eisenhower's signature on August 30. This fact in itself is not an engineering development. However, its implications constitute the most important impetus toward realization of engineering dreams in the field of nucleonics and atomic power since atomic energy came on the scene under Government aegis some 10 years ago.

The new Act provides for private ownership of reactors and facilities and lease by privately owned firms of fissionable materials. It permits commercial production of electric power, engines for propulsion of ships and trains, as well as radiation of materials. The normal patent system will apply to future inventions in the atomic energy field.

The AEC late in the summer established a 5-year reactor program including the construction of:

a) *Pressurized water reactor* by Westinghouse for Duquesne Light Company to produce 264,000 kw of heat or 60,000 kw of electricity.

b) *Sodium-graphite reactor* by North American Aviation to produce 20,000 kw of heat energy. This, it is believed, could be a breeder reactor using U-233 and thorium.

c) *Boiling water reactor* by Argonne National Laboratories to produce 20,000 kw of heat or 5,000 kw of electric energy.

d) *Fast breeder reactor* also by Argonne to produce 65,000 kw of heat or 15,000 electric kw.

e) *Homogeneous reactor* by Carbide and Carbon at Oak Ridge. A second homogeneous thorium of 16,000 electrical kw is planned.

In addition to these four pilot plants, one full-scale and one small experimental reactor, the program includes research in fuel processing, disposal, and waste utilization. The military has received 33 bids on a 1,700 electric kw air transportable package reactor.

The power reactor cost goal of $200 per installed kilowatt is expected with fuel costs of 4 to 7 mils to be competitive with coal and oil. It is conjectured that several million kilowatts of atomic power will be in use by 1965 or 1970, and 100 million by 1980. The first commercially usable power is scheduled before 1960.

The Russians have announced a 5,000-electric kw reactor in use, and a 50- to 100-kw unit in the design stage.

Fifteen private power company groups have organized to study economics and engineering in connection with reactor power. The 26 companies in the Detroit Edison group expect to spend $2.3 million in 1954 on such studies for a total of $8.0 million of private funds.

The U.S.S. *Nautilus*, first atomic-powered submarine, was launched by General Dynamics in January, 1954, with two others to follow. Development of nuclear reactors to propel surface vessels was reinstated under Westinghouse with Bureau of Ships, Bethelehem Steel, and Newport News Shipbuilding. This will be a pressurized-water type.

Industrial applications of isotopes and attendant-control devices such as thickness gauges, level gauges, and pipeline controls, among many and varied others, were stated by the AEC to be now saving industry more than $100 million annually. About 325 beta thickness gauges are in use in United States plants with an additional 100 in Canada and some 300 in West Germany alone.

The most significant instrumentation developments were more in innovation than invention, bringing scalers, scintillation counters, Geiger tubes, survey and prospecting equipment into a higher level of engineering accomplishment. Much emphasis was placed on refining pulse height analysis equipment.

An AEC sponsored survey has indicated that the nuclear instrument business reached an annual rate of about $30 million in 1954, or about a third of the level of the 60-year-old X-ray business.

Geared closely to instrumentation is the radioisotope production program which created it. The AEC shipped about $1 million, and Great Britain's A. E. R. E., $3 million worth of radioisotopes for research, medicine, agriculture, and industrial use. Industrial uses showed the most rapid increase.

Atomic energy or nucleonics has attained the category of big business in 1954, and under greater private and commercial development as compared with Government, this growth should accelerate in 1955. The AEC estimates that today some 15,000 United States firms are working on or are directly connected with the atomic energy program.

Coal and Kilowatts

A. C. MONTEITH
PRESIDENT AIEE

THERE has been a tremendous amount of conversation and writing about atomic power and its eventual displacement of other sources of energy. It is inevitable that the atom will become important in the American way of life. When, in some years from now, more conventional sources of energy begin to disappear, atomic power will be indispensable to our welfare and defense. This day of need for atomic power may not be so far away as might first be suspected, depending on the time scale used. Therefore, we at the Westinghouse Electric Corporation are striving diligently to develop economic efficient atomic-power-generating plants.

Even though one connected with electric equipment manufacturing is close to the problems that beset both the coal industry and the electrical utility, nevertheless, he is in a unique position to consider them in an objective way. It is from such a position of objectivity that President Monteith reviews the future of coal in the electrical utility industry.

At the same time, we believe that the coming of practical atomic power will be evolutionary, not revolutionary. That is why we are, concurrent with our atomic power program, continuing to spend millions of dollars and millions of man-hours in heat-cycle research and in development of better and more efficient power-generating equipment for coal-burning plants. Coal today is more essential than ever in helping to provide the nation's need for electric power. It will be even more necessary in the years ahead.

Let it be established then that coal is basic to the continued growth of the electrical utility industry. But what is the outlook for future growth of the electrical utility industry? Just what kind of market for coal will this growth bring with it?

GROWTH OF ELECTRICAL UTILITIES

FOR the past 50 years, the electrical utility industry has doubled its production of energy every decade. Recently the industry reached 100 million kw of generating capability. And there is no end in sight. The historical rate of increase is expected to continue. It is reasonably certain that there will be about 400 million kw of installed capacity in 1975 and if the traditional rate of doubling every 10 years continues, there will be from 1.5 to 1.8 billion kw by the time the year 2000 appears. Many may say they do not have to worry about the year 2000. But there will be a coal industry and electrical power industry at that time and there will be stockholders to be satisfied.

There are some real opportunities for coal in such a growth picture. Today the electrical utilities constitute the coal industry's largest single customer—taking better than 22 per cent of output. The years to come will find an even larger percentage of this production going to produce electric power.

Today, 50 per cent of all power generated by electrical utilities is generated with coal. Other fuels and water are the additional energy sources.

There are large reserves of coal and it will be economically feasible to market them for some years to come. This is not true of all other energy sources. With them there is the problem of waning supply which, naturally, brings with it increased cost. The combination of the two, short supply and high cost, cannot help but make way for greater use of coal.

Water power will continue to be a factor but will be a minor competitor in the field of energy sources for the electrical utility industry. Most of the desirable sites in the United States have already been developed. For example, the Tennessee Valley Authority was originally constituted as a hydro authority, but now has approximately half of its capacity in steam plants. This is indicative of the problems water-wheel generation faces.

Also, it should not be forgotten that there are going to be some developments that will make it possible to extract the heat energy from coal more efficiently.

The first electrical utility turbine-generator used some 7 pounds of coal to produce a single kilowatt-hour of electric energy. Today, the industry average is 1 pound of coal per kilowatt-hour, and in a modern station it is down to about 3/4 pound. It will be only 2/3 pound per kilowatt-hour when machines such as the 275,000-kw machine Westinghouse is building for the Philadelphia Electric Company are installed.

This is phenomenal progress. In years to come, when similar progress is balanced against utility growth and the afore-mentioned factors of depletion and increased cost of other energy sources, there will still be a big market for coal. As a matter of fact, the electrical utility market for coal will increase at a slightly slower rate than the rate of electrical utility growth. The coal industries may expect to have to supply to the electrical utilities in 1975 at least three times the coal sold to them in 1954.

When we consider energy sources available to electrical utilities in the near future, atomic power is not a significant factor. Again looking in the crystal ball, it is estimated that in 1963, less than 2 per cent of the power generated will be accounted for by the atom.

Essentially full text of an address presented before the National Coal Association, November 18, 1954.

A. C. Monteith is vice-president in charge of engineering and research, Westinghouse Electric Corporation, Pittsburgh, Pa.

THE OUTLOOK FOR COAL

But let us do a little dreaming about the atom. Let us look ahead to the year 2000 and see what may have happened to coal.

Various authorities have estimated varying amounts up to 50 per cent of all electric power generation will be accomplished with atomic power. Strange as it may seem, this should not be alarming to the coal industry. Between the present time and the year 2000, the electrical utility industry will have continued to grow at a tremendous rate. Again, there will be some developments along the line of efficiency of coal-burning plants and some other sources of energy still in the picture. But by the year 2000, the coal industry must be able to produce six to eight times more coal for the electrical utility industry than today if it is to meet its responsibilities. This is approximately twice as much as the total coal mined today for all purposes. This suggests a significant growth potential for the coal industry. It constitutes a tremendous opportunity, as well as a serious responsibility. Undoubtedly, the coal industry has initiated thinking which will build toward a capacity able to supply such an ultimate demand.

But this is not all. There are some other promising growth areas for coal. Already some of the industry's competitors are turning to coal to supplement their products. The natural gas people are eying coal as a raw material source for making gas; and the conversion of coal to chemicals is already under way. In fact, the time may come when mankind will look upon the simple burning of coal as too wasteful of its precious by-products. Indeed, the future of coal abounds with opportunity for growth.

But this is not to say that along with these market opportunities there will not be serious problems for the coal industry in realizing this growth. Not the least important among them will be the need to make coal more economical and more attractive to use in the electric power field.

In a coal-burning plant, about 50 per cent of the cost of producing a kilowatt-hour of energy resides in the coal itself. To electrical utilities and to equipment manufacturers, this strongly indicates an area for study. It should also point out to the coal industry that research and development of production techniques which lead to a reduction in the price of the product would certainly be in order.

Consider what the coal and equipment industries are doing and can do to continue to make coal even more desirable as a fuel for the electrical utility industry.

Basically, the challenge is twofold. It is not only necessary to bring cost down, but to develop more efficient means for using coal.

Opportunities for research and development lie primarily in the direction of cost and price reduction. The key to this is mechanization and modernization. Electricity, the end product of the coal industry's key customer, the electrical utility, becomes an important factor in modernization and mechanization. The manufacturers, who build equipment that can utilize electric power to implement new production techniques, are anxious to co-operate. More power, more tools in the hands of each miner is the solution to lower cost coal at the tipple.

However, efforts toward reducing cost do not end here. Transportation costs represent a sizeable consideration in over-all fuel cost to a utility. The coal industry can go a long way in assuring its future by taking an interest in and helping find a solution to this problem.

Too often, it is assumed that problems involved with coal handling at a power station are ones which utilities, alone, have to solve. Actually, both the coal and equipment industries can help with this one. It is something that has to be considered if coal is to be made a more attractive fuel and a more economical one to use. In coal cleaning and preparation plants there is much that can yet be done to prepare the coal better for the boiler. The equipment industry, too, must develop new products to help improve conveyor systems, coal-burning equipment, and the like.

Finally, the coal industry has an important responsibility to itself to make its product more acceptable to utilities in terms of considerations other than cost. To the utilities, the matter of public relations is of paramount importance. Therefore, for example, they look to the coal industry to help make that fuel clean-burning. Here again, the coal and equipment industries can team up to do the job. Among other things, preparation plants again will have to do a still better job; fly ash precipitators will have to be included if a community is to consider a coal-burning power plant a "good neighbor."

These, then, are some of the important areas for activity on the part of the coal industry in preserving for itself the electrical utility market. The electric equipment manufacturer has a part in these activities, but the initiative in these particular endeavors rests with the coal industry.

EQUIPMENT MANUFACTURERS' ROLE

In making coal more attractive to the electrical utility industry, there is one area in which the equipment manufacturer should, and is, taking the lead. It is in the realm of using coal more efficiently and improving the heat cycle in the generation of electricity.

This would seem to be an endeavor that would decrease rather than increase markets for coal. Actually, the situation is this: Anything that can be done to make coal more attractive, more economical as a fuel, protects its future and expands its potential markets. Coal will grow in importance as a source of energy for the electrical utility industry only as long as it continues to be the most economical fuel. If such a status can be maintained, other fuels will be ruled out and even the advent of nuclear power can be held off. Nuclear power, like anything else, will ultimately have to earn its place in our competitive system on an economic basis.

This, then, establishes the role of the equipment manufacturer in coal's future as an extremely important one.

The boiler maker, for example, is vitally interested in perpetuating coal as the chief fuel for the electrical utility industry. These boiler builders are pouring great effort into new developments in their products.

The same can be said for the builders of coal preparation and handling equipment, and many others.

Westinghouse, too, is betting on the future of coal in the electrical utility industry. Because of this, we are directing much of our research and development into the fields of

metallurgy, fluid flow, chemistry, and the heat cycle, itself. These investigations reflect themselves in the design of turbines, for example, that continue to bring still more horsepower out of every pound of coal. Such research and development has demanded greatly expanded facilities, millions of dollars, and endless man-hours.

We are working with higher steam pressures and temperatures in an attempt to push thermal efficiencies still higher. The Philadelphia Electric Company, with Combustion Engineering and Westinghouse, is pioneering in this high-temperature high-pressure field. The new 275,000-kw Westinghouse turbine to be installed on their system will operate on steam at 5,000 pounds per square inch and 1,200 F, the highest temperature and pressure ever projected and it will have a thermal efficiency of better than 40 per cent.

Developments such as this superpressure turbine stem from such things as better materials, improved blade design, and superior knowledge concerning lubrication and cooling and the flow of steam through the turbine itself.

Westinghouse has built, or is building, three new facilities especially to study these and other related problems. The new Research Laboratory in Pittsburgh is designed to devote increased effort toward accumulating fundamental knowledge of new high-temperature alloys.

At Blairsville, Pa., a new special alloys development plant will soon go into operation. There, scientists will work to develop metals capable of practical application at these higher temperatures and pressures. Their use will permit even a greater amount of the heat energy from coal to be translated into mechanical force to drive a generator.

Westinghouse is dedicating a new multimillion dollar laboratory at South Philadelphia, Pa. It is devoted entirely to research and development in connection with all phases of steam turbine design and application. In addition, some basic research is to be done there in connection with the heat cycle. Some important contributions to the art of wresting energy from coal have already come from this facility.

These few examples certainly indicate that equipment manufacturers are vitally interested in power-generating processes which rely on coal for energy, and that they recognize the important role that coal has to play in our future electrical way of life.

A FINAL WORD ON ATOMIC POWER

Because technical advancement is usually costly, it is often difficult to separate technical and economic progress. The cost of developing atom-powered generating stations is high. This is due, principally, to the fact that development work can be carried only so far on a theoretical or empirical basis. It soon becomes necessary to secure practical experience. This can be obtained only by building and testing and building again. In spite of this, it is absolutely essential that we progress toward more knowledge concerning the atom. In the interests of national defense and economic survival, we must be energetic in our nuclear development programs.

Certain foreign countries, some friendly, some not, faced with lack of fossil fuels and a nearly impossible fuel importation problem, are being forced to move rapidly in the direction of atom-powered generation.

Do not become complacent in the thinking, however, that coal's economic advantage is assured in all places in the United States. There are some areas in this country where coal has had to give economic place to other fuels and to water power. The time may come when these other sources of energy will cease to be able to handle the demands for electric power. It is almost a foregone conclusion that atomic power will be able to compete with coal in these areas if present coal costs persist.

Generally speaking, then, it can be said that atomic power is coming faster technically than it is economically. For that reason, this article has emphasized cost as the key protecting coal's future markets. Coal can continue to be important to the electrical utilities only if it is the most economical source of energy, all things considered.

The coexistence of coal and the atom in the field of electric power generation is neither impossible nor undesirable. What the balance between the two will be in the years to come will depend largely upon the economic advantage one may gain over the other.

The bright future for coal can be assured if all concerned take positive action toward lower costs and more efficient utilization of coal's energy. The challenge to the coal industry is clear cut. Some realistic, far-reaching planning will have to be done now if the coal industry is to lay hold of the opportunities the electrical utility market offers.

Life of Coil Insulation Increased

A completely new coil insulation with 50 per cent longer life than conventional systems is now becoming available on induction motors of 100 to 3,000-hp rating, according to the General Electric Company's medium induction motor department. Described as the most significant development in form-wound insulation in 50 years, the new Polyex insulation increases dielectric strength by 50 per cent and mechanical strength by 600 per cent.

For the first time, the materials in an insulation system are natural insulators in themselves. Previous systems have had cotton or paper bases, which in themselves are not insulating materials.

The material acted only as a spacer to form a dielectric air space between coils. Later improvements included soaking the spacer material in linseed oil, adding insulating materials, and finally the development of cambric cloth, which still utilizes nondielectric materials.

Heat-aging tests of the new insulation show large increases in mechanical and dielectric strength. Resistance to contaminants, shown by salt water immersion tests, is at least twice that of conventional insulation.

In one of the most exacting tests, coil power factor of Polyex insulated coils was substantially lower than coils insulated by conventional systems, because of the tighter, homogeneous character of this newly developed type insulation.

The Hazard of Sudden Darkness

F. H. ELLIS

The evolution of the National Electrical Code—a collection of minimum requirements to safeguard people, buildings, and building contents from the hazards arising from the use of electricity—is traced. In addition the way minimum requirements for emergency lighting were introduced into the Code is discussed.

ONE FACT which emerges with startling clarity from all the coroner's inquests and special investigations which were undertaken are the aftermath of the Iroquois Theater fire of 1903 is that darkness was responsible for more of the 600 deaths than fire itself. All contemporary accounts agree in this: "When that awful darkness fell in the house, the frenzied people did not know where to turn." One account falls unconsciously into a line of classic hexameter verse: "The light of life went out when the electric globes grew dark," but even in the prosaic language of the inquest the meaning is the same. Here is a passage from the interrogation of A. Bernard, house electrician:

Q. Was there a place, as claimed in the morning press, where the auditorium proper could be switched in from a separate line entirely?

A. No, sir.

This "separate line" could not be switched in because it did not exist. There was, in short, no emergency lighting system, and the result was panic.

As reported in the January 1904 *Insurance Engineering*, property damage in this fire "was confined to the immediate neighborhood of the stage . . . . Suffocation and panic are the chief causes of death in such places." The velvet upholstery in the orchestra was not even scorched beyond the third or fourth row and the draperies at the rear of the box were still intact, see Fig. 1. However, Chicago police chief O'Neill described the dead at the exits of the second balcony as like "a field of timothy grass blown flat by the wind and rain of a summer storm."

It is paradoxical that darkness, and not fire, should turn out to be the main hazard of electric lighting. For when buildings were illuminated by kerosene lamps and gaslight, it was widely feared that the introduction of electricity would burn the buildings down. But by the time that every building was illuminated by electricity, the fear was only that the lights might go out. By 1927, a certain A. M. Taylor, an electrical engineer, had convinced himself that "The continuity of supply of light is of more supreme importance than anything else."

Not everyone today will agree with Taylor, but it is nonetheless true that "continuity of supply of light" becomes more and more important as civilization progresses, or is drawn into the atomic age. It is interesting, therefore, to examine very briefly the history of man's efforts to write standards for such continuity.

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This is essentially one story in two parts: First, the story of the evolution of the National Electrical Code, which is a collection of minimum requirements for the "safeguarding of persons and of buildings and their contents from hazards arising from the use of electricity;" second, the story of how, when and why minimum requirements for emergency lighting were introduced into the Code.

The evolution of the National Electrical Code is mainly a story of committees: joint committees, standing committees, working committees, executive committees, rules committees, subcommittees, and committees locked in tedious battles in ages long ago. But these committees and tedious battles are important because they constitute the pedigree of the National Electrical Code, the guarantee that its origins are contractual and democratic, not arbitrary or dictatorial. Every phrase of the original Code of 1897, like every phrase of the 24th edition in 1953, was hammered out at open meetings in which everyone who was interested had a voice. That is why it remains true, as C. J. H. Woodbury said in 1904, that "this Code represents a wider consensus of opinion upon a question of science applied to the service of mankind than ever was concurrently given to any similar subject."

The origins of the National Electrical Code go back in time to the last decades of the 19th century, when local

Courtesy *Safety Maintenance and Production Magazine*

Fig. 1. View of the Iroquois Theatre, Chicago, showing the effects of the fire in the auditorium. Note that damage due directly to the fire itself was confined to the immediate neighborhood of the stage

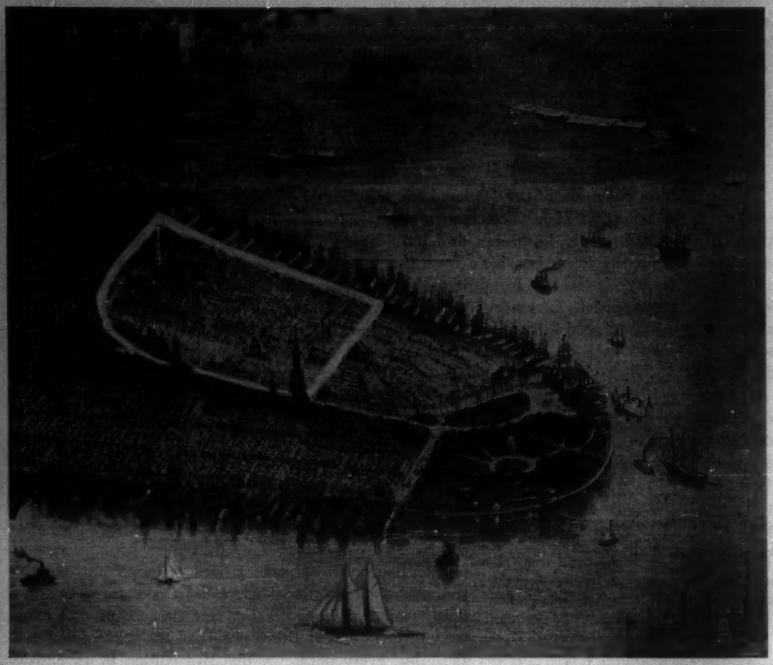

Fig. 2. The first district to be illuminated from a central power station by the Edison Electric Illuminating Company—in the 1880's—is shown outlined in white on this old engraving of New York City

Courtesy Map Department, New York Public Library

boards of fire underwriters began to worry about the application of electricity to millions of dollars worth of insured property. The textile mills of New England were the first large class of buildings to be wired for electric lighting. The sputtering carbon arc lamps strung together on bare wire circuits created such hazards that there were fires caused by electricity in 23 of the first 61 buildings wired for electric lighting which were insured by the Mill Mutual Insurance Companies. In the face of experience like this, insurance underwriters have but two alternatives: either to increase the rates or to reduce the hazard. Actually, the underwriters of 1880 did both, and the rash of "underwriters' rules" which began to appear in 1881 represents the first efforts to cope with the hazard introduced by electric lighting.

Meanwhile, an even more alarming development was taking place in New York. Immediately after its formation in December 1880, the Edison Electric Illuminating Company had set to work to install six steam dynamos at 257 Pearl Street, to lay 95,000 feet of underground conductors, and to take orders for electric lighting in the area bounded by Nassau, Ferry, South, and Wall Streets, see Fig. 2. By then there was ample evidence that electricity caused fires and the prospect that this "dangerous instrumentality" was to be introduced into the crowded city so appalled the underwriters that they voluntarily sought counsel with the lighting promoters. On June 6, 1881, therefore, a committee from the New York Board of Fire Underwriters was entertained at the offices of the Edison Electric Illuminating Company with a "practical demonstration" intended to allay their fears. "Since then," the vice-president of the Edison company reported at the first annual meeting of stockholders, "various interviews with the officers of the Board of Underwriters have taken place, and it is now admitted that the Edison system is free from all danger of fire." Actually the New York underwriters were so far from being convinced that the Edison system was free from all danger of fire that they proceeded to issue on October 19, 1881, the first authoritative rules for electrical wiring in the United States.

On the very next day, October 20, 1881, the Boston Manufacturers Mutual Fire Insurance Company issued the first of a series of reports on the hazards of arc lighting. Special Report No. *11* of this series included rules for the installation of electric lighting formulated by C. J. H. Woodbury. As chief inspector for the Boston Manufacturers Mutual Fire Insurance Company, Woodbury had examined nearly every textile mill in the New England and Middle Atlantic states and the rules which he devised are particularly interesting because they are based on experience of actual fires. Woodbury's rules for the selection of the proper gauge of wire conductor has a refreshing directness and simplicity:

> Any conducting wire which is warm to the touch . . . is liable to become a source of danger and should be replaced by a larger wire.

Woodbury also drew up the *Regulations of the Boston Fire Underwriters Union for the Use of Electric Lighting Apparatus* in 1882 and within the next 10 years some 17 other sets of rules and regulations were issued by various organizations including even a group of salesmen organized particularly for that purpose. Every local board of underwriters issued rules to suit themselves and every inspector interpreted the rules according to his own inclination and predilection.

Such diversity, although very much in the spirit of the period, turned out to be both annoying and expensive. No sooner, for example, had the "electrician" finished stringing the wires along notches cut in the floor joists to admit the now defunct gas pipes, than the insurance inspector arrived to insist that the providential notches were not to be used, in accordance with Article *4a* of the latest rules and regulations issued by the local board of fire underwriters. Diversity also produced some wonderful inconsistencies: in New York, rubber-covered wire was required for concealed work, but in Philadelphia it was expressly forbidden for the same kind of work. And within New York itself, there came eventually to be no less than five different agencies for inspecting electrical work.

In these circumstances, it is not surprising that the utility companies and electrical equipment manufacturers, organized jointly in 1885 as the National Electric Light Association (NELA), should have taken the initiative to produce a single nationally-accepted electrical code. Nor is it surprising that the first efforts to do so were completely abortive. A NELA Committee on Harmonizing Electrical and Insurance Interests failed to do precisely that in 1889. And a NELA-sponsored National Electro-Insurance Bureau produced a completely reasonable and comprehensive set of rules in 1891, but was unable to secure any wide acceptance of them.

It was at this juncture that the insurance interests seized the initiative. On May 1892, C. M. Goddard, Secretary of the New England Insurance Exchange, wrote to every insurance inspector east of the Rocky Mountains inviting him to a meeting in New York to discuss requirements for a standard electrical code. When they convened in August, instead of drafting an entirely new code, the inspectors contented themselves with making amendments and additions to the rules adopted by the NELA Committee on Safe Wiring, which in turn were simply a revision of the rules originally formulated by the National Electro-Insurance Bureau.

In December 1892 the inspectors reassembled, organized themselves into an Underwriters International Electrical Association (UIEA), and appointed a permanent Electrical Committee to formulate and publish, and later to interpret and revise, a standard corpus of electrical rules. The result was the publication, on April 1, 1893, of *Rules and Requirements of the New England Insurance Exchange for the Installation of Electric Light and Power . . . As Recommended by the Underwriters International Electrical Association* and this volume was the immediate precursor of the National Electrical Code.

These rules were adopted almost unanimously throughout the insurance world and, what is much more important from the legal point of view, they were also enacted into law by more than a dozen municipalities. In December 1894, UIEA successfully tested its authority by cracking down on a few underwriters organizations which were allowing deviations from the accepted code to creep into local practice, and, to insure uniformity, the National Board of Fire Underwriters was invited not only to sponsor the rules but also to print and distribute them. At the same time the name of the UIEA was changed to reflect the true scope of the organization. Both of these changes are reflected in the title of the January 1, 1895 edition: *Rules and Requirements of the National Board of Fire Underwriters for the Installation of Wiring and Apparatus for Electric Light and Power, As Recommended by the Underwriters National Electric Association.*

These actions were highly resented, however, in some quarters of the electrical industry. Captain William E. Brophy, who had been a member of the NELA Committee on Safe Wiring, spoke out unequivocally:

> The so-called Underwriters National Electrical Association . . . has arrogated to itself the right to formulate such rules as it pleases for the installation of wiring and apparatus for electric light and power. This body of self-constituted legislators began operations by appropriating as their own the rules issued and copyrighted by the National Electric Light Association which they have since mutilated and added to when it suited their own sweet will without the slightest regard for the wishes and a total disregard of the pecuniary interests of those engaged in any of the electrical industries.

By October 1895, however, the UNEA Electrical Committee felt that their rules were sufficiently well-established to be exposed to general scrutiny and criticism, including that of the electrical industry. It was decided, therefore, that the next meeting of the Electrical Committee should be an open meeting and that the *Rules and Requirements* should be discussed point by point and subjected to a vote in which everyone present might participate. Although it was widely feared that the Electrical Committee would be completely swamped by the votes of representatives of the electrical interests, the event proved quite otherwise.

The reason for this may lie partly in the fact that by this time NELA had regained the initiative in the struggle to produce a national electrical code. In February 1895, a Committee on Standard Electrical Rules had replaced the old Committee on Safe Wiring. In the Fall of that year, the new Committee lined up various national organizations such as the American Institute of Architects, the National Board of Fire Underwriters, and the American Institute of Electrical Engineers in another effort to "undertake the codification, promulgation and enforcement of one standard set of rules, which shall meet as fully as possible the conditions that now exist, and be acceptable to all electrical, insurance and allied interests."

On March 18–19, 1896, representatives of 14 of these organizations met in New York and organized the National Conference on Standard Electrical Rules. A Code Committee was appointed, and Professor Francis B. Crocker of Columbia College was chairman. It was thought an entirely new code to rival the "underwriters' rules" would be promulgated. However, after a detailed comparison of half a dozen of the best existing codes, see Table I, it was very wisely decided to adopt the UNEA rules as the working

Table I. Extract from brochure given delegates to the 1896 National Conference on Standard Electrical Rules to make a point-by-point comparison of existing codes. The four different answers to the question of wire size show the need for a single national electrical code

3. All cut-out blocks when installed must be similarly marked.

4. The safe-carrying capacity of a wire changes under different circumstances being about 40 per cent less when the wire is closed in a tube or piece of moulding than when bare and exposed to the air, when the heat is rapidly radiated. It must be clearly understood that the size of the fuse depends upon the size of the smallest conductor it protects, and not upon the amount of current to be used on the circuit. Below is a table showing the safe-carrying capacity of conductors of different sizes in Birmingham, Brown & Sharpe and Edison gauges, which must be followed in the placing of interior conductors:

Brown & Sharpe		Birmingham		Edison Standard	
Gauge No.	Amperes	Gauge No.	Amperes	Gauge No.	Amperes
0000	175	0000	175	200	175
000	145	000	150	180	160
00	120	00	130	140	135
0	100	0	110	110	110
1	95	1	95	90	95
2	70	2	85	80	85
3	60	3	75	65	75
4	50	4	65	55	65
5	45	5	60	50	60
6	35	6	50	40	50
7	30	7	45	30	40
8	25	8	35	25	35
10	20	10	30	20	30
12	15	12	20	12	20
14	10	14	15	8	15
16	5	16	10	5	10
		18	5	3	5

c. Must have fusible wires or strips (where the plug or equivalent device is not used), with contact surfaces or tips of harder metal, soldered or otherwise, having perfect electrical connection with the fusible part of the strip.

26. TABLE OF CAPACITY OF WIRES:

It must be clearly understood that the size of the fuse depends upon the size of the smallest conductor it protects and not upon the amount of current to be used on the circuit. Below is a table showing the safe-carrying capacity of conductors of different sizes in Brown & Sharpe gauge, which must be followed in the placing of interior conductors:

Table A. Concealed Work		Table B. Open Work	
B. & S. G.	Amperes		Amperes
0000	218		312
000	181		262
00	150		220
0	125		185
1	105		156
2	88		131
3	75		110
4	63		92
5	53		77
6	45		65
8	33		46
10	25		32
12	17		23
14	12		16
16	6		8
18	3		5

By "open work" is meant construction which admits of all parts of the surface of the insulating covering of the wire being surrounded by *free* air. The carrying capacity of 16 and 18 wire is given, but no wire smaller than 14 is to be used, except as allowed under Rules 27 (*d*) and 31 (*a*).

e. Must for 10 amperes and over be provided with contact surfaces or tips of harder metal, soldered or otherwise fastened, having perfect electrical connection with the fusible part of the strip.

25. TABLE OF SAFE-CARRYING CAPACITY OF COPPER WIRES:

It must be clearly understood that the size of the fuse depends upon the size of the smallest conductor it protects, and not upon the amount of current to be used on the circuit. Below is a table showing the safe-carrying capacity of round copper wire conductors of different sizes in Brown & Sharpe, Birmingham and Edison gauges, which must be followed in the placing of *interior* conductors:

Brown & Sharpe		Birmingham		Edison Standard	
Gauge No.	Amperes	Gauge No.	Amperes	Gauge No.	Amperes
0000	175	0000	175	200	175
000	145	000	150	180	160
00	120	00	130	140	135
0	100	0	110	110	110
1	85	1	95	90	95
2	70	2	85	80	85
3	60	3	75	65	75
4	50	4	65	55	65
5	45	5	60	50	60
6	35	6	50	40	50
7	30	7	45	30	40
8	25	8	35	25	35
10	20	10	30	20	30
12	15	12	20	12	20
14	10	14	15	8	15
16	5	16	10	5	10
18	3	18	5	3	5
		20	3	2	3

SECTIONAL AREAS:

P. R.—Rule No. 2. All conductors to have sufficient sectional area, so as to allow at least 100 per cent more electricity being safely sent through them than will ever possibly be required for the lights they are to supply.

By safety is meant that there shall be no perceptible heating of the conductors to the touch; and when proportioning their sizes, the possibility of their sectional areas getting diminished by corrosion or mechanical injury, as time goes on, should never be forgotten. The importance of this cannot be overrated.

Under normal conditions for internal work, the quantity of current sent down a conductor must not exceed the ratio of 1,000 amperes per sectional square inch of copper, when the amount passing through the said conductor does not exceed 100 amperes. Should the amount of current exceed 100 amperes, the ratio, of course, must be less.

It is well to arrange the work when it can be conveniently done so that not more than 100 amperes pass down any single conductor.

The conductors should be of copper, the conductivity of which should not be below 98 per cent of that of pure copper. The use of copper, however, is not obligatory in all cases.

When insulated copper is used, the copper should be "tinned" or otherwise protected from the possibility of any injurious action upon it from the insulation.

All conductors of a larger sectional area than No. 16 S. W. G. should be composed of strands. No conductor of less size than No. 18 S. W. G. should be used except in fittings, and in fittings no conductor should be less than No. 20 S. W. G.

No. 3. No naked conductor or conductors allowed in a building.

Unless in those cases in which special permission has been obtained to the contrary.

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basis for a national code. This prevented a situation from developing similar to that which now prevails in the field of building codes, where it is virtually impossible to secure an agreement of interested organizations on a national scale.

The Code Committee of the National Conference on Standard Electrical Rules submitted its suggestions for additions to and emendations of the UNEA rules to the UNEA Electrical Committee in October 1896. In December, at a joint meeting of the Code Committee and the Electrical Committee, a common text was hammered out and it was decided that the product of these deliberations should be known as the National Electrical Code. Then on May 19, 1897, after the revised rules had already been adopted by the UNEA and the National Board of Fire Underwriters, the Code Committee met again and passed the following resolution:

> *Resolved:* That each delegate who attended the National Conference on Standard Electrical Rules be sent a copy of the Standard Electrical Code, stating that said Code had met with the approval of the Code Committee of the National Conference and the Code Committee of the UNEA, and stating the belief of our committee that there was no necessity for calling the Conference together as a body again, entailing as it would, a very considerable sacrifice of time and money, and requesting their immediate reply if they acquiesced in this recommendation, and approve of the report submitted by the committee . . . In the event of their objecting . . . answer is to be made within 10 days, or their opinion is to be considered as favorable.

When no objections were heard within 10 days, not even from Captain Brophy, the National Electrical Code—unquestionably the most influential and widely used industrial standard in the United States—came into existence, as it were, by default.

In all of these early codes, fire rather than darkness was the hazard which was intended to be reduced or eliminated. None of them so much as mentions emergency lighting, but in 1897, the same year that the National Electrical Code was first published, the Department of Electricity of the City of Chicago was organized. Like so many of the other municipal bodies which at this time began to take over responsibility for the inspection function which had been originally assumed by local boards of underwriters, the Chicago Department issued an *Annual Report* which included a brief description of all fires attributed to electrical causes during the year. In the seventh of these annual reports for 1903, there were accounts of 101 typical fires:

> *February 28, 2:05 p.m.* LaSalle and Washington Streets. Stock Exchange Building. 13-story brick. Fire in attic. Cause: low-tension feed wire run through roof slipped out and grounded to iron-work on roof. Loss, $25.00.
>
> *June 12, 10:02 p.m.* 3977 Cottage Grove Avenue. Occupied by Dr. Frank H. Blackmarr. Cause: a ground on one side of a low-tension circuit and a second contact on the chandelier set up an arc and blew the fuse. This fire was extinguished by the Doctor with a bottle of Vichy water.

But the 102nd of these items was of quite a different nature:

December 30, 3:33 p.m. 79-83 Randolph Street. Iroquois Theater. Cause: Scenery came in contact with arc light on a platform about 10 feet above the stage. Most of the inflammable material on stage and part of auditorium destroyed. Loss, $80,000.00.

This official notice scarcely does justice to one of the most sensational disasters in American history. Everything connected with this tragedy was vast and imposing. The theater itself, which had opened its doors only the month before, was an ostentatious structure in massive French Renaissance style. The opening attraction, a British importation entitled *Mr. Blue Beard*, was equally extravagant. It was a musical "pantomine" featuring a pony chorus, *tableaux*, a troop of "aerialists," pyrotechnics, and a company of 150 artists starring the comedian, Eddie Foy, in a female impersonation, and the dancer, Bonnie Maginn.

The play was publicized in Chicago as a typical holiday attraction: "Don't fail to have the children see *Mr. Blue Beard*" ran the posters and handbills all over the city. And the parents responded magnificently by bringing the children in record numbers. For the Wednesday matinee of December 30, not only were all of the 1,606 seats sold in advance but more than 200 standing room tickets were sold on the day of the performance. Bryan Foy, the six-year old son of the comedian had to watch the performance from the wings because his father had been unable to buy him a seat that morning.

As the second act unfolded before a delighted and responsive audience, Nellie Reed—the principal of the aerial ballet—waited high on a scaffold in the wings to make her leap from stage to balcony during the sensational "Electric Apotheosis" which closed the act. But before the act was over there was an apotheosis of quite a different sort. "At the moment the fire started," as a contemporary account relates, "there was a moonlight scene performed on the stage, and on that account all the lights in the auditorium had been turned out with emergency lights missing. On the stage, nobody seems to have thought of turning the lights on again by throwing the switch and from no other place could that be done; therefore, everything remained dark with the exception of the light produced by the fire itself." In this *Walpurgisnacht* some 600 persons, including Nellie Reed perished in about 12 minutes, see Fig. 3.

For Edwin O. Sachs, who submitted a report on the disaster to the British Fire Prevention Committee in London, "the scenes of panic and reckless trampling were of such a terrible description that they are scarcely fitted for narration." And repercussions of the tragedy were felt throughout the western world. Mayor Carter H. Harrison closed the rest of Chicago's 38 theaters immediately, ordered an investigation into the causes of the fire, and proclaimed January 2, 1904, as an official day of mourning and all day long the bells in Trinity Church rang The Dead March from *Saul*. Kaiser Wilhelm I sent a message of condolence to President Roosevelt and summarily closed the royal opera house at Berlin until the report on the disaster which he had ordered from his consul in Chicago had been received and studied. Theaters in New York were closed when their asbestos curtains failed to pass a blowtorch test instituted by a new fire commissioner. Proprietors of three of Washington's seven theaters were arrested for failing to comply with building regulations, and even in London and Paris theater attendance fell off remarkably.

By January 8, 1904, the Chicago Building Commission submitted its report to Mayor Harrison. Meanwhile, the coroner's jury was demanding that Mayor Harrison, the theater managers, the city electrician, and a dozen others be held to a grand jury on charges of manslaughter. It was in circumstances such as these that the first emergency lighting regulations were formulated in the United States. On January 18, 1904, the Chicago City Council adopted ordinances which included the following rules:

Section 43, Independent Lighting Systems for Exits
All stairways or corridors throughout the buildings of Class *V* (public theaters) shall be supplied with a supplementary lighting system with electricity, gas, or sperm oil, and such system shall be in operation during the entire period such theater is open to the public and until the audience has left the building.

Section 48, Control of Lights
All gas or electric lights in the halls, corridors, lobby, or any other part of every building of Class *V*, used by the audience, except the auditorium, shall be controlled by a separate shut-off located in the lobby, and controlled only in that particular place . . . .

"As to the lessons of this fire," Sachs continued in his report to the British Fire Protection Committee, "there are none that have not long been learned by those versed in the subject of theater safety." As far as emergency lighting is concerned this statement is particularly true, for as early as 1896, William Paul Gerhard, a celebrated German expert on theater safety, had already summarized the lessons of the past 20 years on this subject:

Every theater should, in addition to the gas or electric light, have for the sake of safety an auxiliary system of lighting the passages, corridors, and all stairways and exits by means of oil lamps or candle lanterns so that in case the gas is turned off as happened in the Vienna Ring Theater (1881) and the Brooklyn Theater (1876) fires, or in case the electric light fails, the exits and stairways are not left in total darkness . . . The auxiliary light should be kept lighted from the time the theater is open until the theater and stage are emptied.

Reprinted from *Western Electrician*, November 1903, Courtesy McGraw-Hill Publishing Company, Inc.

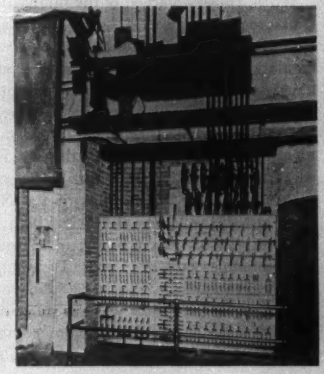

Fig. 3. Particles of carbon from the 2,000-candlepower open-arc floodlight operated on a scaffold by a stage electrician exactly as shown here started the Iroquois Theatre fire. The second of the three main switches at the lower left of the marble switchboard controlled the house lights, which no one turned on when the fire started

At the coroner's inquest, H. H. Hornsby, Chief Electrical Inspector of the City of Chicago, testified that Inspector Tousley of his staff had made 25 or 30 inspections of the Iroquois Theater while it was under construction and that "the management . . . had adopted every suggestion which was offered to improve its safety." Immediately after the fire, Inspector Tousley revisited the theater in order to write the report which was presented to the City Council and which became the basis for the ordinances of January 18,1904.

Almost more than any other man in history, therefore, Victor H. Tousley had an opportunity to observe the awful effects of the *lack* of emergency lighting arrangements. This experience was not wasted. A graduate of Armour Institute of Technology, Tousley became a municipal inspector in 1898 and before he resigned as chief electrical inspector in 1928 to become secretary of the International Association of Electrical Inspectors, he devised a comprehensive set of regulations to implement the emergency lighting sections of the Chicago Electrical Code. For obviously it is not sufficient to enact "a supplementary lighting system" without stating where and how much light is required and how it shall be supplied, together with various rules for the operation and maintenance of the system. These were drafted by Tousley in 1925 and printed in the *Bimonthly Bulletin* of the Bureau of Electricity in January 1926.

1925 also marked the promulgation of the first state regulations for emergency lighting. The Pennsylvania legislature, largely through pressure brought on a yielding senator by a manufacturer of lighting equipment, had passed an emergency lighting law in 1921 simply by amending the Pennsylvania Fire and Panic Act of 1909 to require "a reliable emergency lighting circuit, independent of the main lighting circuit" in all places of public assembly. But the Pennsylvania Industrial Board, which was left to enforce the new law, found out, just as the Chicago Bureau of Electricity had done, that it lacked the detailed requirements necessary to carry out the intentions of the law. In June 1925, therefore, the Pennsylvania Industrial Board issued *Regulations for the Construction, Installation and Maintenance of Emergency Lighting Systems* which, with subsequent amendments, remains the most comprehensive and most exacting set of emergency lighting rules in the country.

When Tousley learned of the publication of the Pennsylvania requirements and heard that California and Wisconsin were also working on drafts of emergency lighting regulations, he recognized that some standardization of requirements would be necessary to prevent a repetition of the chaotic situation which pertained in the electrical field in general before the promulgation of the National Electrical Code. He also believed that the Electrical Committee of the National Fire Protection Association, which had succeeded to the sponsorship of the National Electrical Code in 1911, would be the logical body to undertake such standardization. Accordingly, in November 1928, Tousley communicated with George L. Swan, who was at that time chairman of the Article *39* Subcommittee of the Electrical Committee. This was the subcommittee which was responsible for interpreting and amending the requirements for "Theaters and Motion Picture Establishments" in the National Electrical Code. Tousley proposed that Swan's subcommittee formulate basic requirements for emergency lighting systems. Swan circulated among the members of his subcommittee the rules which Tousley had written for the Chicago code, but it was not until February 1931 that emergency lighting requirements, as finally evolved by the Article *39* Subcommittee, were submitted to a vote of the full Electrical Committee. On this occasion, unexpected opposition developed from the light and power representatives. They were naturally somewhat chary of supporting amendments, the necessity of which arose from the failure of the power which they supplied. So it was not until March 1933, when the power companies withdrew their opposition that emergency lighting requirements finally became part of the National Electrical Code.

The requirements of what is now Article *700* of the Code constitute an adequate safeguard against the hazards of accidental darkness. But, unfortunately, these requirements are not mandatory, even when the Code is enacted into law. It is specifically stated in Article *700* that the provisions of this Article are applicable only "where such systems are legally required by Municipal, State, Federal, or other codes, or by any governmental agency having jurisdiction." Several states and many municipalities which have adopted the National Electrical Code have failed to provide the additional legislation necessary to validate the requirements of Article *700*. The truth of the matter is that state legislatures and city councils have remained unaware of the need for emergency lighting until it has been forced on their attention by some local disaster. The original Pennsylvania Fire and Panic Act of 1909 was the legislative response to a whole series of disasters of which the most sensational was the destruction by fire of Rhoades' Opera House in Boyertown. Similarly the Coconut Grove night-club fire which claimed 492 victims in Boston was followed by a wave of panicky lawmaking which extended into neighboring states. The New Hampshire legislation enacted on this occasion was even entitled the "Coconut Grove Law" and naturally it included provisions for emergency lighting.

But it should not be necessary to kill people by the hundreds in one state after another in order to secure adequate emergency lighting legislation. The National Electrical Code is ready at hand to supply an authoritative answer to the question *how*, and all that the legislature must decide is the question *where* emergency lighting systems should be installed. And even here the Code itself provides the best direction:

> Emergency systems are generally installed in places of assembly where artificial illumination is required, such as buildings subject to occupancy by large numbers of persons, hotels, theaters, sports arenas, hospitals, and similar institutions.
>
> Emergency systems may provide power for such functions as essential refrigeration, operation of mechanical breathing apparatus, ventilation when essential to maintain life, illumination and power for hospital operating rooms, fire pumps, industrial processes where current interruption would produce serious hazards, public address systems, and similar functions.

This knowledge has been hard wrung from a great deal of human suffering, suffering which might have been avoided if the requirements of Article *700* of the National Electrical Code had been legislated into existence.

Practical Design of Transmission Line Tensions

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PRECISE CALCULATIONS are seldom justified in the determination of the sags and the tensions of transmission lines, because the effect of many of the variables bearing on tension are indeterminate: no practical equation exactly describes a suspended cable; the conditions of conductor loading are, of necessity, idealized; the elastic properties of conductors are not constant; and additional errors are inevitable during construction. However, the catenary is taken as the form assumed by a suspended cable, the equation of which is $y = C\cosh\frac{x}{C}$. For these reasons, the equation for center sag can be expressed with sufficient accuracy for ordinary conditions as

$$S = \left[\frac{L^2}{8C} + \frac{1}{6C}\left(\frac{L^2}{8C}\right)^2\right]\sec\theta$$

where

S = sag at center of span
L = span length
C = catenary constant
θ = angle of inclination of the chord

Sag is the only tangible and controllable factor in transmission line design. Good practice and regulatory bodies set a clearance below which the conductors must not lie, and economy dictates that this clearance must not be exceeded. Maximum tensions are likewise prescribed, but practical considerations generally make this a value that, while it must not be exceeded, can only be approximated. Therefore, in some cases, the errors arising from using approximate formulas for sag calculations are not critical if clearance is not critical. These errors depend on L, C, and the difference in elevation of the supporting structures, and the maximum sag error for any combination of these three factors may be determined.

Where the length and slope of an inclined span is such that the error of the preceding equation is beyond desirable limits, the level span of which the inclined span is a part can be readily determined and the clearance calculations subsequently made from the level span.

The equation of the level span is

$$L_e = L + C\log_e\left[\frac{\sqrt{\left(\frac{2C}{L}\sinh\frac{L}{2C}\right)^2 + \tan^2\theta} + \tan\theta}{\sqrt{\left(\frac{2C}{L}\sinh\frac{L}{2C}\right)^2 + \tan^2\theta} - \tan\theta}\right]$$

The right hand term may be set up in tabular form to expedite the solution.

The amount of plastic flow, which takes place in all metals, affects the final sag in all spans. This is particularly true at high tensions. Several methods of providing for plastic flow during the installation of conductors are in general use.

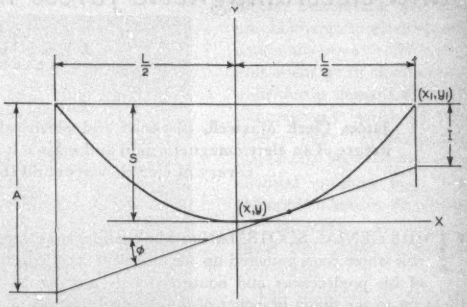

Fig. 1. Method of sagging using unequal intercepts

Where spans of a series are separated by vertical suspension insulators, each span will influence the behavior of every other span of the series. If the spans are reasonably well distributed, an equivalent span may be determined which will have the same characteristics as the series. The value of the equivalent span is $\sqrt{\frac{\Sigma L^3}{\Sigma L}}$ where ΣL^3 is the summation of the cubes of the spans and ΣL is the total length of the series. However, there are limitations to this method which prevent its indiscriminate use.

For sagging purposes, the conductor can be brought tangent to a line of sight which is parallel to the chord and below it by the amount S. However, it is sometimes difficult and usually inconvenient to establish such a line of sight. A more flexible method of adequate accuracy is to use unequal intercepts at the conductor supports. Considering the level parabola of Fig. 1, it may be shown that

$$S = \left(\frac{\sqrt{A} + \sqrt{I}}{2}\right)^2$$

This equation may be applied to a catenary with considerable accuracy, in ordinary cases, where the ratio between I and A is as high as 4 to 1.

The design of transmission line tensions by precise but time-consuming methods is justified in unusual cases, but approximate and faster methods may be used to solve the problems encountered in the great majority of lines. However, these approximate methods are to be used with caution and only with a thorough knowledge of their limitations. Like a mechanic, the designer selects the tools that will most quickly produce satisfactory results.

Digest of paper 54-501, "Practical Application of Sag and Tension Calculations to Transmission Line Design," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1955.

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TEN FOUNDING FATHERS OF THE ELECTRICAL SCIENCE

X. JAMES CLERK MAXWELL

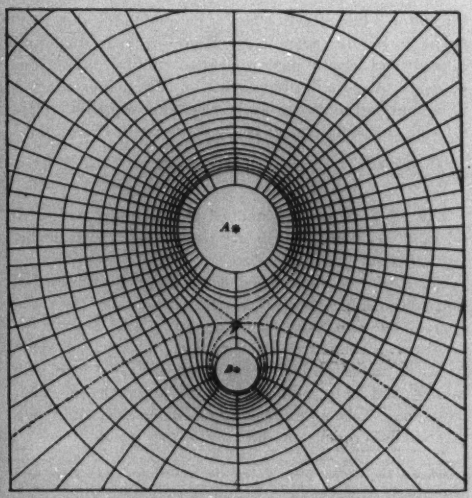
and electromagnetic forces mathematically demonstrated

BERN DIBNER
FELLOW AIEE

James Clerk Maxwell, physicist and electrical experimenter, mathematically developed the nature of an electromagnetic field and related it to the nature of light. His work led to the discovery of electric waves and the mechanical pressure of light.

THIS GENIAL SCOTSMAN can be considered as the oak whose roots gathered up the electrical knowledge of his predecessors and contemporaries and passed them on to the many branches of the physical sciences of today. He was the product of the universities of Edinburgh and of Cambridge (Trinity), the school of Newton and Darwin.

Maxwell's interest in the physical sciences was at first general and included special studies in the behavior of gases, the interchange of forms of energy, and of optics. From 1860, when he was awarded the Rumford Medal by the Royal Society for his studies in light, to 1866 when he resigned his academic work to retire to his estate at Glenlair in Scotland, Maxwell experimented and wrote on these varied physical topics. The swing towards a primary interest in electricity and magnetism became definite when the British Association Committee endeavored to determine a set of electrical standards in 1862. It was under Maxwell's direction that experiments began to fulfill this requirement. The vague theory which Faraday had noted in 1832 in which he compared the diffusion of magnetic forces from a magnetic pole to ripples on water, to sound or to the vibrations of light, Maxwell clarified in firm mathematical demonstrations in his "Dynamical Theory of the Electrodynamic Field," published in 1865. In this paper Maxwell treated the transmission of electric and magnetic forces through a medium in mathematical terms and concluded with the electromagnetic theory of light. The same approach was followed in the preparation of Maxwell's most important publication, his classic "Treatise on Electricity and Magnetism" that appeared in 1873 in two quarto volumes. The first scientific contribution was a paper presented before the Royal Society of Edinburgh when Maxwell was only fifteen. The inspiration that was to hold him throughout his life appeared shortly after his graduation from Cambridge as a memoir entitled, "On Faraday's Lines of Force."



Lines of Force and Equipotential Surfaces as shown in Maxwell's, "Elementary Treatise on Electricity," 1988

Although regarded as unnecessarily complex by his contemporaries, the mathematical treatment in defining electrical and magnetic relationships, the increasing complexity of electrical usage, and the training of electricians and physicists in subsequent generations has prompted them to refer to Maxwell for a clear understanding of these basic relationships. His contact with Faraday at the Royal Institution where Maxwell lectured in 1861 made him admire not only Faraday the man but also Faraday the experimenter. Maxwell was engaged, in particular, by Faraday's concept of the nature of the space or field existing around a magnetized or electrified body (so remarkably revealed by iron filings). Maxwell thereupon decided to study this field and to give its properties mathematical expression. He realized then, as we do increasingly today, that there was more knowledge concerning the laws relating to matter, motion, and energy than grasp and understanding of that which seemed to pervade everything and yet was resolved to nothing. He realized that "the work of mathematicians

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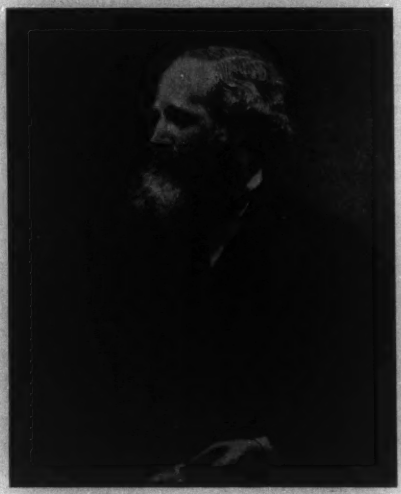
is of two kinds, one is counting, the other is thinking," and he regarded thinking as a nobler though more expensive occupation than counting. He wished to represent the physical universe not in directionless symbols, denoting mere quantities, but in dynamic vector terms in which one could think about a material system in a relative position of its parts. The mind had to shift from a three co-ordinate system to a point of space having magnitude and direction. Thus, the phenomena of static electricity, electromagnetic attraction, electrical induction, and diamagnetism were viewed as the products of actions that proceed in an excited body and its surrounding field. Applying his equations to the propagation of a magnetic disturbance through a nonconducting field, he concluded that the velocity of propagation "is so nearly that of light, that it seems we have strong reason to conclude that light itself—including radiant heat, and other radiations if any—is an electromagnetic disturbance in the form of waves propagated through their electromagnetic field according to electromagnetic laws" and "Light consists in transverse undulations in the same medium which is the cause of electric and magnetic phenomena." In these terms, the concept of the electromagnetic field coupled with Ohm's law as a basic principle, he established the electromagnetic theory of light, and deduced therefrom the common operating laws of electricity and magnetism. Then light, electricity, and magnetism became extensions of the same operation.



After a painting by Dickinson

James Clerk Maxwell

Maxwell investigated the kinetic energy that possibly might be possessed by an electric circuit when in rapid motion and in 1861 he constructed an apparatus to determine its value. The apparatus consisted of a central electromagnet capable of being rotated about its horizontal axis between pivots, and a ring which revolves about a vertical axis. There was independent neutralization of the earth's field and the pivots were used as conductors to energize the coil. Any possible angular movement of the coil towards the vertical was observed during the rotation of the ring. Maxwell operated the device and concluded that if a magnet contains matter in rapid motion, the angular momentum of such rotation would be very small compared with any measureable quantities. He also constructed a dynamical model to demonstrate the equations of electric currents, as in the case of two inductive circuits.

In 1871 Maxwell was appointed the first professor in the newly founded chair of experimental physics at Cambridge and he devoted himself to the task of establishing the Cavendish Laboratory, a fountainhead of physical knowledge where Ohm's law for metallic conductors was verified. It was fitting therefore that shortly thereafter Maxwell also should edit the electrical research of Henry Cavendish, the earliest of quantitative electricians. At Cambridge, the birthplace of nuclear physics, experiments were made important to the electromagnetic theory, establishing that the unit of charge in electromagnetic units bears a ratio to the unit of charge in electrostatic units that is numerically and dimensionally equal to the speed of light. Maxwell predicted that light exerted mechanical pressure and this prompted Crookes to devise the radiometer to demonstrate this phase of energy conversion.

The existence of electromagnetic waves had been indicated by Maxwell's equations. It was 15 years later that Heinrich Hertz of Karlsruhe demonstrated the existence of such electromagnetic waves in the space about a discharging Leyden jar. Later Hertz expanded the experiments by using induction coils joined to metallic sheets and balls. The spaced second conductor having a small gap in its circumference showed that oscillatory discharges took place between the metal sheets in the form of sparks appearing in the gap of the secondary detector. Hertz calculated the value of the velocity of propagation in the air and found it, as Maxwell had predicted, to be the order of that of light. This evolved into signalling through space and has expanded from this beginning into modern radio communication.

In 1860 the Royal Society presented the Rumford Medal to Maxwell for his research in light and in the following year he presented his first lecture at the Royal Institution under the sponsorship of Faraday, one whom Maxwell admired more than anyone else among his colleagues. Maxwell delivered the inaugural lecture at the Cavendish Laboratory in 1871, but actual research did not commence there for another 3 years. He sponsored popularization of difficult scientific subjects and contributed his own "Matter and Motion" as an example of such a simple and lucid presentation. He wrote delightful humorous poetry, often poking fun at his colleagues. He was especially honored to receive, in 1878, a doctorate and the Volta Medal from the University of Pavia, the school where Volta taught. The void left by the early death of Maxwell at the age of 48 is still felt as efforts to understand the physical world move on towards the paths as originally outlined by this consummate interpreter.

Effect of Reduced Voltage and Frequency

O. D. BUTLER
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C. J. SWENSON
ASSOCIATE MEMBER

CENTRAL station auxiliary motors are designed to carry their rated loads with specified terminal voltage and frequency. Experience has shown that, in most cases, a 10-per-cent-reduction in voltage will not prevent motors from carrying normal load or cause dangerous heating.

To determine the effect of voltage reductions greater than 10 per cent as well as the effect of low frequency, a series of tests was run on a representative group of auxiliary motors at the Calumet Station of the Commonwealth Edison Company. This station was selected as a test site because it has both old as well as modern equipment. The old plant consists of 18 chain-grate stoker-fired boilers rated at 300 pound per square inch gage supplying six condensing turbines, while the high-pressure plant consists of two 1,250-pound-per-square-inch-gage pulverized coal boilers supplying unit 7, a 107-megawatt condensing turbine, and also a pressure-reducing and desuperheating by-pass station to supply a limited amount of steam to the old plant.

To confine the tests to auxiliaries only, it was necessary to isolate a low-pressure turbine-generator unit and several 12,000-volt and 2,300-volt busses from the system because the station carried its normal share of customer load with normal voltage and frequency during the tests.

The tests were run in three steps:

Test 1. The voltage of the generator supplying the auxiliaries was reduced in steps of 250 volts from 12,000 volts to 8,750 volts with frequency constant at 60 cycles.

Test 2. The frequency of the supply generator was reduced from 60 cycles to 53.2 cycles in approximately 1-cycle steps, maintaining the voltage constant at 12,000 volts.

Test 3. Both voltage and frequency of the generator was reduced in the following manner: starting with 11,220 volts (10 per cent below full load value of 12,500 volts) and 60 cycles, further reductions were made in steps of 350 volts accompanied by frequency reductions of approximately 1 cycle down to 9,520 volts and 55.1 cycles.

While some effects were noticed on all auxiliaries during the tests such as changes in speed and motor current, only two auxiliaries (both part of the high-pressure plant) were critically affected. These were the coal mill (with integral exhauster) and the high-pressure boiler feed pump.

The effect of low voltage was to increase the mill motor current to the point where it approached the setting of the over-current relay. This relay normally operates when the mill becomes overloaded with coal and stops the coal feeder to prevent further additions of coal until the mill has partially freed itself. Under the test conditions this relay could easily operate to reduce the fuel feed to the boiler, thereby reducing plant capability.

Under reduced frequency, with or without voltage reduction, the coal mill slowed down to where the resulting burner flame receded to an unsafe point.

No effect of consequence was noted on the high-pressure boiler feed pump as a result of low voltage. However, both low frequency and combined low frequency and voltage caused the pump speed to reduce rapidly to a point where it could no longer pump the required feedwater to the high-pressure boilers.

To assist in evaluating the tests, a curve was prepared in which the total auxiliary power current was plotted versus voltage and frequency. Under reduced voltage a gradual rise in current was noted up to the point where the voltage was 18 per cent low. Beyond this point, the current increased more rapidly so that the 18-per-cent value appears to be critical because of the danger of motor burn-out. Operation at 18 per cent below normal would appear feasible for short periods only. Reducing frequency caused a direct reduction in total current and also a direct slowing down of all auxiliary motors. Observations showed the coal mills to become critical below 56 cycles and the high pressure boiler feed pumps critical below 57 cycles.

When frequency and voltage were simultaneously reduced, the auxiliary power current dropped drastically below 57 cycles and 18-per-cent-voltage reduction. However, observations during this test showed that the high-pressure boiler feed pumps had slowed down prior to this time to the point where three motor-driven pumps could not maintain the necessary feedwater flow to the boilers. A study of the test data show that under reduced voltage conditions these boiler feed pumps become critical at 58 to 59 cycles.

In interpreting these tests, any indication that an auxiliary is affecting or is likely to affect the maximum steaming rate of a plant must be considered critical. The effects mentioned in the foregoing were far beyond what could be tolerated and still produce full output of the plant. After careful study and evaluation of the results of these tests, the following conclusions were drawn:

1. A voltage reduction of 18 per cent could be tolerated for a short period with no deleterious effect to the auxiliaries at Calumet Station.
2. While test 2 shows that 57 cycles is critical, it is believed that straight frequency reduction is not a desirable means of load relief.
3. Test 3 shows that under reduced voltage conditions, 58 to 59 cycles is a critical region. Under such emergency conditions, the frequency would undoubtedly be dropping at a rapid rate so that any corrective action should start before a critical auxiliary situation develops.

The conclusions are true only for Calumet Station and cannot be applied to other stations without careful study.

Digest of paper 54-368, "Effect of Reduced Voltage and/or Frequency upon Steam Plant Auxiliaries," recommended by the AIEE Committee on System Engineering and approved by the AIEE Committee on Technical Operations for presentation at the Fall General Meeting, Chicago, Ill., October 11-15, 1954. Scheduled for publication in *AIEE Power Apparatus and Systems*, vol. 73, 1954 (Feb. 1955 section).

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Silicon Alloy Junction Diode as a Reference Standard

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MEMBER AIEE

THE ADVENT of transistors and junction diodes and their incorporation into telephone equipment has increased the importance of the regulated metallic rectifier as a source of low-voltage d-c power. It has been found possible to replace vacuum tube and magnetic amplifier regulating circuits in these power supplies with equivalent, and usually more compact and efficient, semiconductor apparatus.[1]

An important component of any feedback-type regulating system is the error detector which compares the system output to a reference quantity. Several types of reference standards are used in regulated rectifiers, including batteries and glow tubes. An important new type of standard has been developed, based on the observation, by G. L. Pearson and B. Sawyer of the sudden breakdown effect in silicon junction diodes.[2]

Several of these sample diodes were obtained and tested by passing current through them in the reverse direction and noting the voltage drop. It was observed that very little current was passed by the diode until the "breakdown" or saturation point was reached. Beyond this point, each diode exhibited a very low resistance or slope, the magnitude of which seemed to be related to the value of the saturation point. Another effect noted was that the reverse characteristic curves were translated by changes in ambient temperature.

It was determined that if a diode were biased to operate in the saturation region, a source of fairly constant voltage drop was obtained that could be used as a standard of reference. The slope value and the temperature translation effect were seen to be primary causes of systematic error in the reference. Therefore methods of defining the slope and temperature coefficient were developed as shown in Fig. 1.

Further tests on a larger scale confirmed the relationship between temperature coefficient, slope, and breakdown voltage.

Diodes having reverse breakdown voltages as high as 36 volts had slopes approaching 1,000 ohms and temperature coefficients on the order of +0.1 per cent per degree C, and diodes having breakdowns from 4 to 6 volts had slopes approaching 10 ohms and temperature coefficients of about +0.01 per cent per degree C. Since it is usually desirable to obtain reference standards with zero temperature coefficient and very low slope, future investigations were limited to the low-voltage diodes.

About 60 diodes having reverse breakdown voltages between 4 and 6 volts were then tested. Temperature coefficients and slopes were then plotted. These diodes were also tested in the forward direction, using the criteria shown in Fig. 1, and it was determined that the temperature coefficient of the forward drop was always negative, but

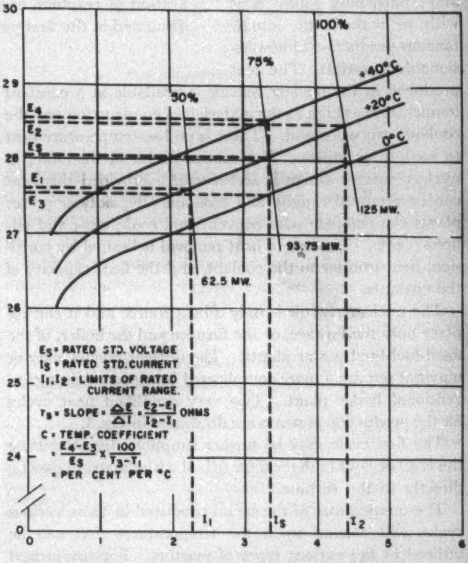

Fig. 1. Derivation of slope and temperature coefficient

was independent of forward breakdown voltage at about 0.16 per cent per degree C, and that forward slope was almost a linear function of this forward breakdown voltage.

Thus it is thought that the silicon junction diode, biased past the saturation point in either the forward or reverse direction, can serve as a source of low-voltage reference potential in feedback regulating circuits. Single diodes should be selected that will give reference values of about 6 volts in the reverse direction for optimum results. If other values of reference voltage are desired, the diodes can be connected in series, either anode-to-anode or anode-to-cathode to give various values of slope and temperature coefficient.

Digest of paper 54-417, "The Suitability of the Silicon Alloy Junction Diode as a Reference Standard in Regulated Metallic Rectifier Circuits," recommended by the AIEE Committee on Metallic Rectifiers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 11-15, 1954. Scheduled for publication in AIEE *Communication and Electronics*, vol. 73, 1954 (Jan. 1955 section).

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Nuclear Power Reactors

STUART McLAIN

Since controlled nuclear fission was first demonstrated 12 years ago, great progress has been made in the development of nuclear power. Practical reactor materials and coolants, classification of reactors, and three reactor types are discussed in the first part of this 2-section article.

THE NUCLEAR reactor is a device for conversion of the potential energy of fission of uranium and plutonium into heat with or without the simultaneous production of new fissionable materials. The heat produced in the nuclear reactor is available at a constant temperature as high as the materials of construction and the coolants can withstand. There is no low-temperature heat to recover or utilize. The central problem, therefore, in nuclear reactor design is *heat removal*. Provided this heat can be removed rapidly and economically, nuclear power plants can compete with conventional coal-, gas-, and oil-fired plants. The *rate* of heat removal is limited by corrosion, heat transfer to the coolant, and the heat capacity of the coolants.

The nuclear reactor is only a heat source and it can replace only the furnace, or the furnace and the boiler, of the fossil-fuel-fired power plants. The nuclear reactor may or may not require a more complicated heat cycle than a conventional boiler plant. Two very simplified heat cycles for the production of steam are illustrated in Fig. 1.

The first cycle may be further simplified by permitting the H_2O or D_2O in the reactor to boil with the steam passing directly to the turbine.

The temperature of the steam produced in these various cycles will depend upon the temperatures that can be utilized in the various types of reactors. For pressurized water reactors, the pressures will be less than used in coal-fired plants now being built, and there will be no superheat. Reheat cycles are possible, but they have not been studied to date. In the case of the liquid-metal-cooled reactors, the liquid-metal temperatures will be high enough that some superheat can be provided and reheat cycles appear practical. In those cases in which relatively low-pressure saturated steam is fed to the turbines, the corrosion rates in the turbines will be increased since liquid water will be present on the blades at higher temperatures than in the case of higher-pressure superheated steam. Further, in steam cycles fed with saturated steam, the steam must be removed from the turbine at least once for dewatering. No work has been done to date on the use of reactors as superheaters or reheaters. In large central stations making use of more than one nuclear reactor, it may prove advisable to use liquid-metal coolant in at least one reactor in order to provide the high-temperature heat required for superheaters and possibly for reheating. Oil-fired superheaters may prove to be economical, but only a small fraction of the heat of combustion would be available at high temperatures and the low-temperature heat would have to be recovered. Only the briefest work has been done on these problems.

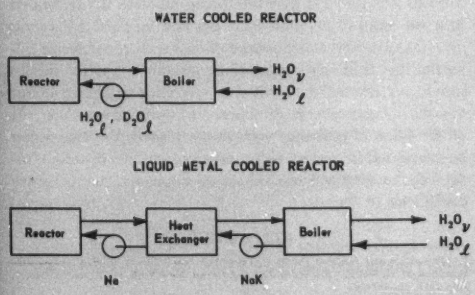

Fig. 1. Two simplified heat cycles for production of steam

The nuclear reactor consists of fuel in a suitable form; fertile material to produce new fuel; usually, neutron moderating materials; coolant; fuel cladding and structural materials; shielding materials; means for loading and unloading fuel assemblies; and sensing instruments for neutron density, temperature, etc. Since each requirement may be met in several ways, it is obvious that there is a large number of possible variations in nuclear reactor types. It is this fact that makes a discussion of nuclear reactors so confusing.

Fig. 2 shows a cut-away drawing of the Argonne Research Reactor with the various parts indicated by arrows. In this reactor the heavy-water coolant and moderator is pumped up through the fuel assemblies and flows outward at the top of the assemblies into the tank. It then flows out the bottom of the tank to the heat exchangers and pumps. The fuel assemblies consist of highly enriched U-235 in an alloy with Al, clad with Al, in the form of plates. Several plates are fabricated into a fuel assembly. A graphite zone and experimental facilities were provided which would be omitted in a power reactor.

Most reactors built to date have been of the heterogeneous type with the fuel present as rods or flat plates. Several reactors, notably those built at Los Alamos and Oak Ridge, have been of the homogenous type. In homogeneous reactors the fuel is dissolved or slurried in the coolant and circulated with the coolant.

The first part of a 2-section article recommended for publication by the AIEE Committee on Nucleonics and presented at the AIEE Fall General Meeting, Chicago, Ill., October 11–15, 1954.

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A different way to classify reactors depends upon the manner in which the fission reaction takes place. Neutrons are emitted in the fission reactions at various velocities and energies up to perhaps 15 mev (million electron volts), and an average energy of about 2 mev. These neutrons will cause fission in nuclear fuels, but the amount of fissionable material in the reactor may be larger and in more concentrated form than in an equal power thermal reactor. If the neutrons are slowed down by permitting them to impact on low-atomic-weight materials such as hydrogen, deuterium, carbon, and beryllium, they will react with U-235 more readily and thus the weight of the U-235 present may be only 0.1 to 0.01 that of a fast reactor. Those reactors built to use virgin or fast neutrons are called fast reactors, while those built to use slow neutrons are known as thermal reactors, since the neutrons have the same energy as monatomic gas molecules at the same temperature.

The neutron cross sections (probabilities of neutron reactions) of several elements and isotopes for several types of reactions are listed in Table I.

Table I. Cross Sections, Barns (10^{-24} square centimeter/nucleous)

Isotope or Element	Thermal			Fast			
	Non-Fission Capture	Scattering	Fission Capture	Non-Fission Capture	Scattering	Inelastic Scattering	Fission Capture
H	0.33	20–80		5×10^{-3}	4.5		0
D	0.0005	7.5					
C	0.005	5		10^{-3}(?)	3		0
Na	0.50	3.5		0.0014	3		0.3
Fe	2.4	11		0.005	3		1
Bi	0.03	9					
U-235	107		580				> 0
U-238	2.75	8.3					> 0
Pu-239	315		750				> 0
Th-232	7.0	13					0.3

Inelastic scattering occurs with heavy elements by neutron capture with neutron emission at lower energies. It should be noted that 16 per cent of the U-235 atoms that capture thermal neutrons do not fission and that 30 per cent of the Pu-239 atoms that capture thermal neutrons do not fission. U-235 emits 2.54 neutrons per fission, and Pu-239 emits 3.0 neutrons per fission in the thermal range.

POWER REACTOR DESIGN

Several groups of very competent engineers have made economic studies to determine what type of reactor should be most economical for the production of power. These studies have indicated that several types have sufficient promise of producing economic power to justify development. At the present time, too many factors are unknown to permit accurate calculations of all factors. For example, it is always necessary to assume a life for the fuel element, life of the reactor, maintenance and operating costs, fuel fabrication costs, and irradiated fuel recovery costs. The rate of heat transfer that can be allowed ought to be easily settled; but the internal stresses in the fuel elements, phase changes in the metals, possibility of boiling effects of corrosion films, etc., make decisions difficult. The maximum permissible temperatures in the fuel elements and the corrosion rates determine the temperature drops. For these reasons, the designs which have been prepared for large-scale power reactors have been inherently conservative.

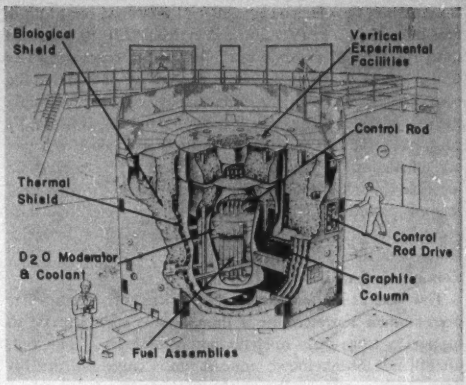

Fig. 2. Argonne Research Reactor

Some of the practical materials under serious consideration today for use in thermal and fast heterogeneous and homogeneous reactors are shown in Table II.

Table II. Practical Reactor Materials

	Thermal	Fast
Fuel	U-233, U-235	Pu
Fertile	Th, U-238	U-238
Moderator	H_2O, D_2O, C, Be	
Coolant	H_2O, D_2O, Na	Na, Bi
Structure, clad	Al, Zr	s.s.

Most nuclear engineers would prepare a slightly different list of materials. Note that no gases such as He, CO_2, or air are included. Gas coolants can be shown easily to be uneconomical due to high pumping costs if the heat is to be used to produce steam. If the gas can be heated to 1,400 F or so, gas turbines might be economic or dual systems might be considered.

The practical reactors that may be built in the near future from the materials shown and which appear to be economic are listed in Table III by name.

Table III. Reactor Types

Pressurized water, H_2O, D_2O
Boiling, H_2O, D_2O
Water or sodium cooled, graphite moderated
Fast
Homogeneous, UO_2SO_4 water solution, Bi

There are a number of questions that should be discussed here, such as: "Why these particular materials?", "Why U-233 in thermal reactors?", and "Are there large enough quantities of uranium and thorium available?".

Consider the fuels first. The conversion ratio, defined as

the atoms of new fissionable material produced per atom of fuel burned in a reactor, may vary from 0.70 to 1.0 or so in thermal reactors and up to 1.5 or so in fast reactors. The term, "breeding," is used loosely. Usually, it means that the conversion ratio is over 1.0, and it is frequently used to imply the same fuel is produced as is being fissioned. It is usually considered that U-233 is the best fuel for thermal reactors and plutonium is the best fuel for fast reactors since these materials give the highest conversion ratios in these types of reactors. Both U-233 and plutonium are extremely hazardous materials when taken internally, being of the order of 10^6 and 10^7 as potent as the most dangerous cancer-forming chemicals.

The world's known supply of uranium and thorium has been studied to determine if the amounts are adequate to support a large-scale nuclear power industry. The rich pitchblende Shinkolobwe mine in the Congo and the Eldorado mine on Great Bear Lake, Canada, produced before World War II. Discovery of additional mines was slow until a drive to build up uranium production began in 1948. Since then, explorations have been pushed and have proven to be very fruitful. Many discoveries have been made on the Colorado Plateau and in other parts of the United States. Production has been doubling every 18 months with even greater expansion rates appearing to be ahead. The United States' uranium industry has passed the $100,000,000 per year mark. Canada, in addition to the Great Bear Lake area, is an important producer, and Australia, Portugal, and other countries have some production. The South African gold mines promise to be one of the world's largest uranium producers. Here the uranium is essentially a by-product of the gold production and, while the concentration of uranium in the ore is low, enormous tonnage of the gold ore is produced. Similarly, uranium is being produced as a by-product of phosphate production.

Thorium ores are less well known. India and Brazil are known to have large deposits. No widespread search has been made for thorium.

More practical and immediate questions are those relating to cost of recovery and the rate of supply of uranium and thorium. If it is assumed that new ore bodies will be found to replace those mined out, there will be a sufficient supply at $10 per pound or so to support a large-scale power industry in the world's free areas. An expansion of 20,000,000 electric kw per year is considered reasonable in a decade or more, and much of this will probably be nuclear powered. Both the rate and amount of supply appear to be adequate for many years for a large-scale nuclear power industry even without breeding.

Because of the low neutron absorption cross sections of the U-238 and thorium, large amounts must be used in reactors to produce new fuels, so the physical inventories are high. For an expansion of 20,000,000 electric kw per year, the inventory could be increased by 10,000 to 15,000 tons. The actual burnup is small. With breeding, only 500 tons or so per year would be burned to produce all the electricity now used in the United States, and only 1,000 tons would be burned to supply the present electric load for the entire world. Without breeding, the rejected low U-235 might be twenty times this amount. Losses in the fuel fabrication and chemical plants may equal or exceed the burnup.

Within a not unreasonable maximum cost of $100 per pound for the oxides, it appears that in terms of energy, uranium and thorium must be evaluated in tens of times the amounts of the fossil fuels. Moreover, British newspapers have stated that the British are working on the controlled fusion of light elements. If successful, this would add practically an infinite source of energy.

Natural uranium can be partially enriched in the diffusion plants. So there is available partially enriched uranium with a U-235 content up to 1.5 per cent or so, which permits the building of light-water-cooled and moderated and sodium-cooled graphite-moderated power reactors. Natural uranium may be used in heavy-water-cooled and moderated and in light-water-cooled graphite-moderated plants. The lowest cost fissionable material is the U-235 in natural uranium.

Those countries which do not have diffusion plants are planning heavy-water reactors. Fully enriched U-235 is used in research reactors in this country. One reason for

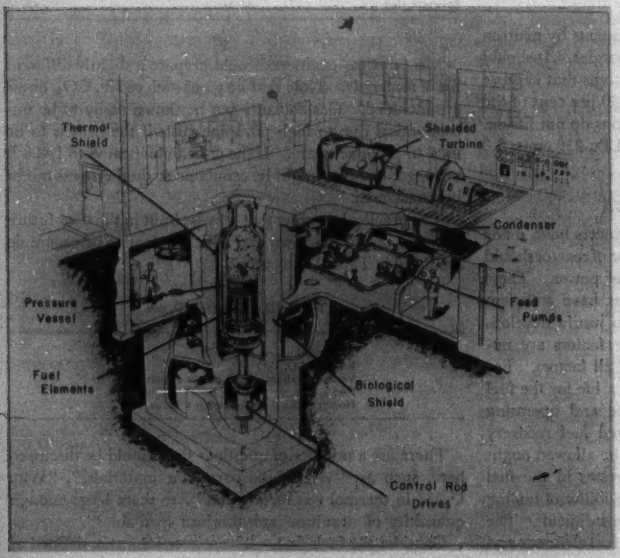

Fig. 3. Boiling experimental reactor

the International Atomic Energy Pool and the law changes is to permit the United States to export partially enriched uranium for use in research, and in research and power reactors in other countries. India, for example, with help from the International Pool, could start U-233 thorium cycle reactors. Uranium enriched to as much as 10 to 20 per cent would be satisfactory for these uses.

Uranium may be used in a heterogeneous reactor in the form of rods, plates, or tubes. Rods have been extensively used because of the ease of production and cladding. In the early reactors, large rods were used in order to clump the fuel to limit resonance absorption in the U-238 and maintain criticality with natural uranium. The result was small surface area and low power. To obtain high power levels required for economic power, the fuel must be present in thin plates or small-diameter rods. Perhaps, 1/4-inch diameter is the maximum economical size. Enriched uranium has been used in research reactors as an alloy with aluminum.

Uranium is an anisotropic metal in the alpha phase (up to 1,225 F). Unless properly heat treated, it will develop a bumpy surface, warp, and change over-all physical dimensions if heated and cooled a few times. Under irradiation, it may crack because of high-thermal stresses or otherwise alter its shape. Thorium is a cubic metal and stable. Both uranium and thorium can be rolled and machined readily.

Usually, metallic uranium and thorium are used because of the high heat-transfer rate; k, Btu per hour square feet degree F per foot, for uranium is about 15, equal to s.s. Protecting the uranium and thorium against corrosion by the coolants has been a major concern. Of the common elements, aluminum is the only material that has low neutron cross section and reasonable corrosion resistance. In high-purity water, 2S Al can be used up to 400 F without excessive corrosion rates; intergranular corrosion starts at about 525 F. Aluminum was chosen as the cladding material for most of the early experimental and production reactors, such as Hanford. Bonding of the can and fuel to promote heat transfer is desirable. As an example, an alloy of aluminum and silicon may be used as a bonding material.

For power reactors, higher temperatures are desirable. While aluminum may be used, the temperatures are limited and the thermal efficiencies low. Zirconium may be used up to 550 or 600 F and stainless steel up to perhaps 1,000 F or higher with water. Stainless steel has a high thermal neutron-absorption cross section and zirconium has been expensive, $12 to $15 per pound, before fabrication. Zirconium is readily fabricated.

Another type of fuel element is that used in the sodium-cooled reactors. In these reactors, zirconium or stainless steel may be used at high temperatures and cooled with sodium. Bonding is simple. Liquid sodium is simply poured into the cladding tube to provide metallic heat-transfer rates. Closure of the fuel elements has been a problem. As noted previously, stainless steel may be used in fast reactors. An extensive program of nondestructive tests has been carried out to provide adequate inspection.

Homogeneous reactors avoid these problems by dissolving the fuel in the coolant. A suitable system consists of 5 to 10 grams of uranium per liter as $UO_2.SO_4$ in a heavy-water solution. Liquid metal solutions, fused salts, or slurries may be used.

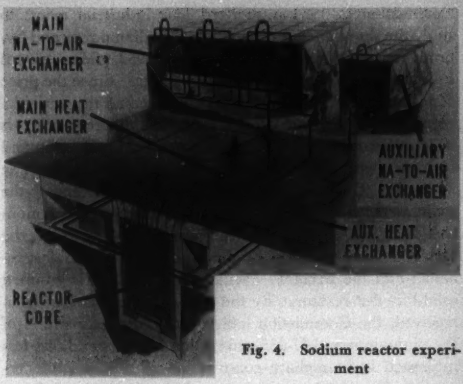

Fig. 4. Sodium reactor experiment

COOLANTS

The coolants mentioned earlier are H_2O, D_2O, and Na D_2O is produced at the Dana and Savannah River Plants. While the actual production costs per pound are classified, they are much less than the normally quoted cost of $80 per pound. The main problems involved with coolants are corrosion, transport of corrosion products, and maintenance of purity. Water also decomposes under irradiation, and the hydrogen and oxygen must be recombined or diluted to eliminate danger of explosion. Water purity may be maintained by ion exchange and sodium purity by cooling and freezing out most of the impurities such as sodium oxides.

POWER REACTORS

The present status of the development of power reactors is a logical outcome of the work carried on in the Commission Laboratories and by the Industrial Contractors in the past few years. During the war, a graphite and a heavy-water reactor were built at Argonne, and an air-cooled graphite reactor was built at Oak Ridge. Graphite production reactors were built at Hanford. A heavy-water reactor was also built in Canada at Chalk River. In 1948, a new program of construction of experimental reactors began, namely the Brookhaven reactor, the submarine reactors, the Materials Testing Reactor, the Experimental Breeder, and the Experimental Homogeneous Reactor. The development, construction, and operation of these reactors has resulted in very important accomplishments. The Experimental Breeder and Homogeneous Reactors have produced token quantities of electrical power and the submarine prototype reactor has operated successfully. No operational difficulties of tieing the reactor power system into existing grids occurred. Also, the reactors have responded to load demands very readily and almost automatically.

While the above reactors were still under construction, the

Commission in 1951 authorized four industrial teams to study the simultaneous production of civilian power and by-product weapon-grade plutonium. In 1952, all four groups submitted cautious, but favorable, reports. Since the price of plutonium was not specified, this became the variable. Significantly, all four groups suggested different reactors which they considered feasible and practical to develop and construct with the co-operation of the Commission. The Monsanto Chemical—Union Electric group chose the sodium-cooled graphite-moderated reactor; the Commonwealth Edison—Public Service group, the heavy water; the Dow Chemical—Detroit Edison group, a liquid-fuel fast reactor; and the Bechtel—Pacific Gas and Electric group, a solid-fuel fast reactor. By the time these reports had been received, the Commission had authorized an expansion of the plutonium and U-235 production facilities and was less interested in immediate construction of dual-purpose reactors. During these years, the Laboratories and Commission Contractors had suggested the construction of several pilot reactors for the production of power.

The various reports were studied by the Commission in view of the Commission's needs at that time. It was decided to drop the dual-purpose phase of the power-reactor program and to place emphasis on the civilian aspects of the program. Estimated construction and operation costs were reviewed and a program developed for construction of pilot and full-scale reactors.

During the summer of 1953, the Joint Congressional Committee on Atomic Energy held hearings on the possibilities of economic nuclear-power plants. These hearings resulted in a request by Congress for a specific program for development of power reactors. The Laboratories and Industrial Contractors co-operated with the Commission in producing the Five Year Plan which was submitted to Congress and implemented after hearings by appropriations in 1954. This Five Year Plan calls for developing and constructing five different types of power reactors and some special fuel fabrication facilities.

GOVERNMENT PROGRAM

The first of the five authorized reactors is a full-scale, not a pilot scale, Pressurized Water Reactor. In this reactor, light water at high pressure is pumped through the reactor and a heat exchanger or boiler to produce steam.

The development and design of this reactor has been assigned to the Westinghouse Electric Company as a logical extension of their work on pressurized water submarine reactors. Construction will be started next spring near Pittsburgh by the Duquesne Electric Company which will supply the turbine and generating facilities and operate the plant. The 600-psi saturated steam will produce at least 60,000 kw of electric energy. The steam will be bled from the turbine for dewatering at low pressure and three feed-water heaters will be used. The reactor will produce about 300,000 kw of heat.

Slightly enriched uranium will be used in the zirconium-clad fuel plates. The direct cost of the plant can only be estimated as the budget costs include considerable development work. The pressurized-water reactor is the only type that has been considered to require no pilot plant.

The General Electric Company has announced an interest in building a large-scale pressurized-water graphite-moderated reactor. This is an extension of their work on operation of the Hanford production reactors.

The second reactor is a pilot-sized boiling light-water moderated and cooled reactor similar in basic design to the pressurized-water reactor, except that the steam is produced in the reactor core by boiling. This reactor as developed by Argonne National Laboratory has a simplified flowsheet in that the intermediate heat exchanger and circulation pumps are eliminated, see Fig. 3.

Zirconium-clad flat-plate fuel elements made up into assemblies similar to those used in Argonne's Research Reactor will be used with slightly enriched uranium. Unloading and loading of the fuel will be carried out through the top of the reactor. The control rods are driven from below the reactor. A steam accumulator, to partially level out pressure surges, will be used between the reactor and turbine.

The 600-psi steam will carry its radioactivity into the turbine; therefore, the turbine and condenser must have no leaks. Corrosion products from the turbine and condenser may be carried back into the reactor. While these problems probably can be solved, the rate of heat production in the reactor may be lower than in the nonboiling type.

It is hoped that these questions can be answered by constructing a reactor at Argonne National Laboratory. The reactor is being developed and designed by Argonne. Sargent and Lundy has been chosen as the architect engineer. Allis Chalmers will supply the power-producing equipment. The reactor will produce 20 megawatts of heat and 5,000 kw of electric energy. Construction is to be started in the spring of 1955. While this reactor is being built for use with light water, tests with heavy water may be run later.

The design of this boiling reactor is based on experiments carried out at Arco in 1953 and 1954. A small water-cooled and moderated reactor was set up, and conditions imposed that normally would be expected to cause an excessive power rise. It had previously been assumed possible that the core would melt and release the fission products under the conditions of the test. When excess reactivity was added very rapidly, rapid power excursions occurred, but the formation of steam in the core ejected the moderating water, shutting off the nuclear reaction before dangerous temperatures occurred. Extrapolations of the test data indicate that instantaneous additions of excess reactivity up to 3.8 per cent would be self-limiting without serious damage when the reactor water is at the boiling point. With the water in the nonpressurized reactor at room temperature, instantaneous additions of excess reactivity up to 1.9 per cent would produce similar effects. With 3.8 per cent excess reactivity, the power level of a reactor of this type rises a factor of e (2.718) every 0.0024 second and with 1.9 per cent excess reactivity the power rises a factor of e every 0.0065 second. No regular operating reactor would ever be built so that more than perhaps 0.5 per cent excess reactivity could be added in a short time. This half of 1 per cent is less reactivity than represented by

the delayed neutrons. The experiments definitely demonstrated the inherent safety of pressurized-water and of boiling-water reactors, although the exact data hold only for the particular reactor under test.

The third reactor is a pilot-scale sodium-cooled graphite-moderated reactor modeled in some respects after the Hanford production reactors. This reactor has been under development by North American Aviation. It will be designed by North American and built at their Santa Susanna Site some 25 miles north of Los Angeles, starting in the spring of 1955. The reactor will use slightly enriched fuel rods, stainless-steel clad, and sodium cooling. Arrangements will be made so that the graphite moderator can be replaced. The sodium will leave the reactor at 875 F. The heat will be transferred to NaK, sodium-potassium alloy. No power-production facilities are planned, even though some 7,500 kw of electricity could be produced from the 20 megawatts of heat. The reactor is shown in Fig. 4.

The advantages of the sodium-cooled reactor over the water-cooled reactors are the higher surface temperatures of the fuel elements permitted as there are lower corrosion rates with subsequent high-thermal efficiencies, low-pressure operation of the reactor, and high heat transfer rates. Disadvantages are the additional heat-transfer and pump equipment that must be added, the difficulties in loading and unloading, the induced radioactivity of the sodium, and the noncompatability of sodium or NaK with water and air. Even though two heat exchangers must be used in series to prevent the radioactive sodium and boiling water from coming into contact with one another in case of a tube break, the costs may not be excessive since the heat transfer film coefficients are high—of the order of 20,000 to 30,000 Btu/square foot hour degree F. This compares with 7,000 to 10,000 Btu/square foot hour degree F for water.

(Description of the other two reactors and the industrial program will appear in the February issue.)

Progress of Carrier and Microwave in Power System Operation

C. W. BOADWAY

New developments in the power-line carrier system have resulted in increased operating ranges, improved noise characteristics, and greater reliability of equipment, so that it has progressed far beyond the original concepts of those first associated with it.

IN the power utility field, it is an accepted fact that power-line carrier provides a communication medium which, in many cases, is more practical, economical, and reliable than other forms of communication. While it is accepted, the method is not as widely recognized as it might be. In view of past performance, however, it is best to become acquainted more fully with the services that can be provided by power-line carrier and the basic techniques involved.

OPERATING PRINCIPLES AND APPLICATION

"POWER-LINE CARRIER" or "carrier current" is a technique whereby intelligence is conveyed between points in an electric utility system utilizing currents in the approximate frequency range 400 to 300,000 cycles per second. Fundamentally, the method involves the superposition of one or more high-frequency channels on a power circuit without interference to, or from, the power system. In general, high-frequency carrier energy is applied between one of the line conductors and ground (known as phase-to-ground coupling) or between two conductors (known as phase-to-phase coupling), as indicated in Fig. 1. Thus, transmission of signals is accomplished via the power conductors, rather than by radiation into free space as in conventional radio applications.

In its basic form, a power-line carrier channel consists of transmitting and receiving devices operating at a frequency within the aforementioned range, coupling devices to convey the high-frequency signals to and from the line, and one or more conductors of the power line. Transmission of intelligence is accomplished by one of several methods: keyed carrier; amplitude modulation; frequency modulation; frequency shift; and pilot or suppressed-single-sideband carrier. The method of transmission depends on the type and concentration of services, and on the physical and electric power circuit characteristics. Where circuits are noisy, for example, frequency modulation or single-sideband operation provides improved signal-to-noise ratios over conventional amplitude-modulation transmission. When a large number of channels is to be provided at one terminal station, the use of single-sideband transmission

A special article recommended by the AIEE Committee on Carrier Current.

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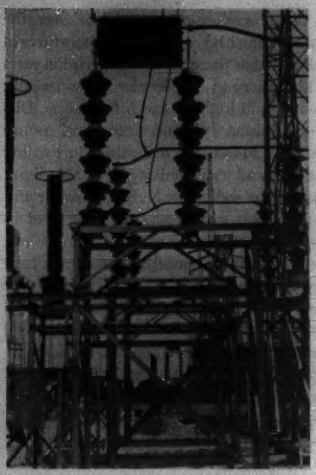

Fig. 1. Power-line carrier connections

will permit closer channel spacing thus allowing more channels to be operated in any given portion of the available carrier spectrum.

Power-line carrier is, as a rule, a single-channel device, and is employed to provide voice communication, telemetering, load-frequency control, teletype, supervisory control, and protective relaying facilities to aid in the efficient operation of a power network. In some cases, however, two or more functions are combined on the same carrier channel to alleviate channel crowding, such as, telemetering and relaying services which may be combined to operate over a single channel, provided the primary relays can take control during power system disturbances.

Fig. 2. Typical carrier terminal, incorporating voice duplex and tone channels for telemetering and control functions

Fig. 2 shows a typical carrier terminal incorporating voice duplex and tone channels for telemetering and control functions.

In power system operation, system control and protection are of primary importance. Power-line carrier channels provide an effective and reliable means for the utilization of relay and load-frequency control signals. The use of telemetering services provides the means by which a centrally located supervisor may observe and follow his over-all system conditions, and with automatic load-frequency control, full advantage of the system generating capacity is realized. Through the use of high-speed carrier relaying with automatic reclosing, tie-line load control, or both (see Fig. 3), a power system may be operated much closer to stability limits. This permits optimum use of existing facilities and resultant savings in investment. High-speed selective tripping, or blocking of circuit breakers by carrier relaying, contribute materially to service continuity of the power network. This is accomplished by minimizing the time during which fault conditions can involve adjacent circuits and equipment of the power network.

HISTORY

At the turn of the century it was found that high-frequency currents below 300 kc would follow wires more readily than they would travel through space. Between 1900 and 1920, several important developments were made in equipment, and by 1923, at a time when radio broadcasting was in its infancy, power-line carrier telephony was a well-established means of communication. Most of the early equipment, of course, appears crude by comparison with modern standards. The first equipment utilized 250-watt vacuum tubes for the final carrier-frequency amplifier in the transmitter. Today, because of improved receivers and auxiliary devices, outputs as low as 1 or 2 watts are in common use. Also, the isolation, by means of resonant line traps, of power terminals and power-line taps has greatly simplified the problem of carrier-equipment application by reducing carrier-transmission losses, thus increasing reliability.

By 1923, 2-frequency duplex equipment, which made it possible for intelligence to be transmitted and received without the use of push-to-talk devices, was in commercial production. As power-line carrier was applied more extensively, many uses other than telephony were developed. Among them were selective control of circuit breakers in 1923, phase-comparison relaying in 1933, and remote control by carrier in 1934. In 1936, a system of telephony, relaying and supervisory control using power-line carrier, was placed in regular service.

In connection with relaying service, vacuum tubes became available in 1936 which would give satisfactory power output with plate voltages as low as 100 volts. As a result of this development, the reliability of power-line carrier equipment was greatly improved and maintenance costs were effectively reduced.

DEVELOPMENTS

The years following 1940 marked what probably has been the greatest development period in the applica-

tion of power-line carrier. During this period, modern distance- and phase-comparison-carrier relaying, fast automatic reclosing circuits, and high-speed circuit breakers received considerable attention and were greatly improved in both performance and reliability. These developments, together with improvements in carrier-control relays, resulted in more stabilized operation of the modern power system by providing simultaneous tripping of the breakers at each end of a faulted power circuit. The resulting dollar savings are of such consideration that electric utilities can no longer underestimate the value of fast carrier relaying with automatic reclosing on all main power trunks and system interconnections.

Recent years have seen marked improvements in almost every phase of the carrier application field. New developments have resulted in increased operating ranges and improved noise characteristics. This has resulted in improved reliability, particularly under adverse weather conditions. Improvements have been progressive in the development of frequency-modulation equipments, in single-sideband equipments, in auxiliary tone units, in electronic transfer units used in voice-operated communication channels, in the reliability and quality of component parts such as tubes, transformers, etc., in line coupling and trapping equipments, and last but not least, in the knowledge and technique of applying equipments to the power system. Today, electric-utility communication and relay engineers have proven facilities available to solve the complex relay, communication, and control problems associated with a transmission system.

It is necessary that careful consideration be given each new carrier application so that the equipment selected will adequately accomplish the required purpose, and the proposed channel will co-ordinate with existing carrier facilities. Many applications may be combined economically with existing services and, in some cases, it may be very desirable to retire old and obsolete equipment. Carrier networks have grown so rapidly that it has been difficult to apply over-all system planning. This implies the need for more intelligent planning and direction of future installations.

Power-line carrier today is no longer of the nature of an art, but rather it is a successful, scientific engineering solution to power system communication problems. Development and progress in this field are quite evident when it is realized that, to date, the total investment in carrier and associated equipment in the United States approximates $250,000,000. Future developments of power-line carrier promise to be both rapid and interesting. This is illustrated by the present trend towards the use of broadband coupling devices and multichannel carrier equipment. In this respect, it is conceivable that power lines may be employed ultimately for the transmission of higher-frequency energy as guided or surface waves.

MICROWAVE

Under most conditions power-line carrier is a practical and economical service. It makes use of power lines at no sacrifice to their performance, and provides excellent facilities for communication services. However, this type of channel medium has been used so widely by some power systems that the provision of additional service channels is becoming increasingly difficult. This condition is being improved continually by developments in equipment and application techniques. Some organizations are using other means of transmission and have added carrier extensively to telephone circuits underbuilt on the transmission line right-of-ways. Others are looking to allied communication media such as microwave radio which will offer a flexible communication system, particularly in applications not readily suitable for power-line carrier facilities. Microwave refers generally to beamed radio transmission using frequencies of the order of 1,000 mc and above. With elevated antennas, such as shown in Figs. 4 and 5, distances of the order of 30 miles or more may be spanned. Longer distances are covered by automatic relaying through spaced repeater stations. Microwave is adaptable to the superposition on the radio circuit of a number of multiplexed channels for simultaneous transmission of varied intelligence.

Fig. 3 (left). Typical terminal. Fig. 4 (right). Elevated antenna for microwave system

Fig. 5. Microwave antenna and 154-kv structure

Fig. 6. Microwave equipment

The demand for microwave systems for power utility applications has increased due to the necessity for expansion of communication multiple services, and where present alternative facilities are not considered adequate or economical. The advantage of microwave lies in its ability to provide a large number of basic channels which can be used for a variety of purposes.

Telemetering, power relaying, supervisory control, load control, teletype, trunk dialing (see Fig. 6), as well as voice channels, may be applied to a microwave installation. Microwave lends itself readily to expansion since once the basic installation has been established, further facilities can be added without influencing the existing channels. Planning and construction of a microwave communication system can proceed almost independently of the power system network. An established microwave system provides facilities for the installation of base stations in a mobile radio system. Most microwave stations are established at points of high elevation and are provided with antenna towers and other facilities which constitute a major expense in the installation of land-mobile base stations. The multiplex feature of microwave systems provides an opportunity to plan remote control of land-mobile base stations from one or more convenient locations within the power system.

Success and improvement in the performance of microwave installations is because, in large measure, of recent developments in electronic tubes and circuitry. Duplicate equipment with automatic rapid transfer and alarms, diversity reception to overcome propagation problems, and emphasis on standby power supplies are recognized techniques of the microwave engineer to provide the power utility with a versatile communication medium of utmost reliability.

Power system communication has been developed far beyond the original concepts of the engineer who was associated with it 25 years ago. Technical achievements have given new answers to the old problem of ways and means of conveying intelligence for power control, and as improved techniques are further developed, the power utility will no doubt continue to apply them progressively to their fullest advantage.

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Electronic Unit Probes Behavior Patterns of Fires

An electronic device with 14 temperature-sensitive "feelers" is helping firemen to "see through the smoke" and know more about conditions inside a burning house.

The device, built into a two-story house erected on the campus of the Miami Fire College, Miami, Fla., to probe the behavior patterns of fires as part of the college's research efforts, was designed to develop new fire-fighting techniques. Developed by Minneapolis-Honeywell Regulator Company's industrial division, the electronic recording instrument indicates temperatures throughout the burning building and charts the findings. Strategically spotted "feelers" or thermocouples, the temperature-sensing elements, are imbedded in the walls, ceiling, and floors of the building to feed back temperature readings.

"The day has long passed when fire fighters idled away time playing checkers," said Chief Newton L. Wheeler. "Today's fireman is kept busy brushing up on old skills and developing new techniques in the science of fire fighting," he added.

The temperature-monitoring system played a large part in helping the college to develop and perfect such new techniques as the use of a "fog nozzle" and the use of "wet water."

The "fog nozzle" directs a cloud of water on the fire, not a heavy stream. Experiments proved that such water could absorb more heat than a heavy stream and more rapidly reduce the temperature of the burning region, as well as temperatures at the opposite end of a building.

"Wet water" is produced by adding a wetting agent, similar to a dishwashing detergent, to plain water. The wetting agent breaks down the surface tension of the water, increasing the heat-absorption qualities of the water. Use of this wetting agent reduces by some 95 per cent the amount of water needed to douse a fire.

Loss Formulas from Functions of Voltage Angles

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ASSOCIATE MEMBER AIEE

A NEW APPROACH in the form of remarkably simple formulas for the determination of incremental transmission losses in electric power systems has been advanced by Brownlee.[1] He derived the formulas for the simplest possible transmission system of two generators connected by a single transmission line, and then showed that they were applicable to practical power systems by working out some numerical cases. Brownlee's formulas are functions of the phase angles of the generator bus voltages, so that their application is restricted to those cases where the phase angles are known, such as a-c network analyzer studies.

The purpose of this article is: to provide a more solid foundation for Brownlee's results, showing some of the conditions which must be satisfied for their validity; to provide additional numerical examples of the successful use of Brownlee's theory; and to provide an extension of Brownlee's theory to give expressions for incremental and total losses which do not require knowledge of phase angles. It is believed that the method of calculating incremental and total loss coefficients, which is presented, is considerably simpler than any yet advanced.

The demonstration of the applicability of the Brownlee formulas to practical systems hinges on the finding of an analytical method of exchanging generation between two plants. One possibility is to take advantage of the fact that a considerable variation in the power flows has only a relatively small effect on the voltages at the loads, if the generating station voltages are held fixed. Then, if one plant has its voltage phase angle increased at constant magnitude, holding the voltage of another plant fixed in both magnitude and phase, and holding the currents of all other plants and all loads fixed in both magnitude and phase, the result will be an approximation to the desired condition where generation is exchanged between the two plants with no other changes in the generations or in the loads. The low impedance of the transmission system connecting the two generating stations allows a large change in their currents with only small voltage changes on the system. Any changes in power at the other generating stations and at the loads are a result of the small voltage changes acting on a fixed current. The results of applying this procedure to a transmission system agree with Brownlee's simple results, except for the addition of generally small correction terms. In particular, when the R/X ratios of the transmission lines do not vary excessively in the system, it may be expected that the correction terms will be negligible.

It is thus clear why the Brownlee formulas can work on practical systems, and why the proper impedance to use is the one measured with all loads disconnected.

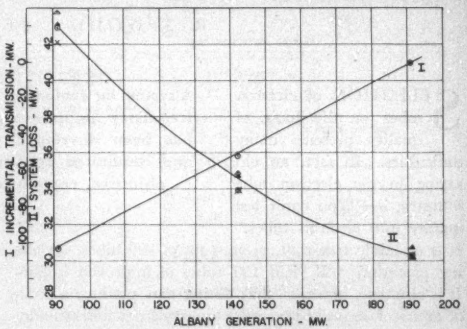

Fig. 1. Comparison of actual and calculated losses for exchange of generation between Albany and Oswego

— = network analyzer values, ⊙ = Brownlee angle formulas, × = incremental losses coefficients, ▲ = new total loss coefficients, △ = Kirchmayer coefficients

Assuming the validity of the basic angle formulas, a new derivation of incremental and total loss formulas is

$$\frac{dP_L}{dP_{n-M}} = \sum_m A_{nm} P_m \tag{1}$$

$$P_L = \sum_n \sum_m P_n B_{nm} P_m \tag{2}$$

The assumption that each load has a fixed percentage of the total system load power is required. The required data are a base-case load-flow study, and the open-circuit self and mutual resistances and reactances between the generating stations. The mutual impedances between the generators and the loads need not be measured.

Incremental and total loss formulas have been derived by the new method for a representation of the 110-kv transmission system of the Niagara Mohawk Power Corporation. It is shown by comparison with network analyzer results that the new loss formulas are suitable for economic scheduling problems. An example of the comparison between the power losses calculated by I^2R and the losses calculated by other means is given in Fig. 1.

On the basis of the theory and numerical results it is concluded that the Brownlee theory and the new loss formulas are applicable, at least in those cases where all important transmission is at the same voltage level.

Digest of paper 55-25, "The Determination of Incremental and Total Loss Formulas from Functions of Voltage Phase Angles," recommended by the AIEE Committee on Systems Engineering and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31-February 1, 1955. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1955.

C. R. Cahn is with Syracuse University, Syracuse, N. Y.

REFERENCE

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Quality Screening for Audio-Frequency Impulse Noise and Microphonism

R. J. WOHL STANLEY WINKLER

A system for evaluating electron tubes for audio-frequency impulse noise and microphonism has been developed with easily constructed and duplicated apparatus. The procedure is objective, reproducible, and repeatable.

SELECTION of electron tubes on the basis of quality presents many difficulties. In fact, an old saying in the electron tube industry is—"You can't test quality into electron tubes." It is certainly true that, given a lot of 100 tubes, no testing procedure will yield 100 tubes of improved quality. It is also true, however, that testing can produce a group of tubes of improved average quality from this same lot, provided one can accept the necessary shrinkage. To accomplish this, it is merely necessary to have valid testing procedures for the characteristic under consideration.

Until very recently, no satisfactory procedures were available for audio-frequency impulse noise and microphonism. A system for evaluating tubes for this parameter which is objective, repeatable, reproducible, and possesses at least *a priori* validity has been developed at the Naval Material Laboratory.[1] This system has been applied to the very problem of "testing quality into electron tubes" by the technique of screening. By screening is meant simply acceptance and rejection on the basis of a predetermined acceptable quality level.

NAVAL MATERIAL LABORATORY SYSTEM

THE essential elements of the new system are an exciter and an indicator. The exciter consists principally of a precisely specified pendulum supported so that at the bottom of its fall it strikes the envelope of the electron tube under test. This pendulum tapper is shown in Fig. 1. Sufficient flexibility of adjustments is provided to permit delivery of the impulse to any point on the envelopes of electron tubes of various sizes and shapes. The magnitude of the blow is determined by setting the angle of fall of the pendulum arm.

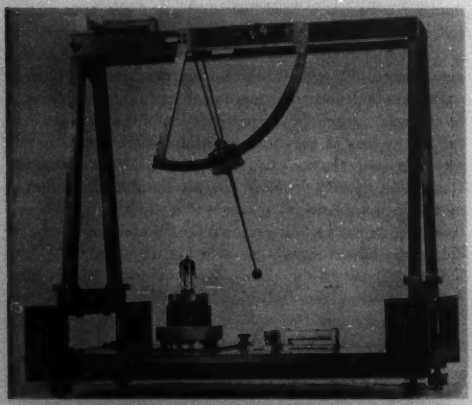


Fig. 1. The pendulum apparatus for evaluating vacuum tubes for a-f impulse noise and microphonism

The use of gravity insures constancy of driving force over long periods of time and in different localities. The steel bearing ball, which serves as the pendulum bob, introduces a sharp impact directly into the tube envelope, thereby providing a wide frequency band of excitation. In addition, the bearing ball is readily obtainable and standardized as to composition and hardness. The energy available in the pendulum arm prior to impact is determined solely by its mass, mass distribution, and dimensions, all of which are specified by manufacturing tolerances to a fraction of 1 per cent.

The operational results confirm the expected high repeatability of this pendulum tapper. The coefficient of variation for repeated measurements of the output of a Sperry-MIT pickup, which was struck by the pendulum, was less than 2 per cent. This figure includes variation introduced by the observer, the pickup, and associated equipment, as well as that due to the tapper itself. The reproducibility figure (coefficient of variation) obtained by comparison of two equipment models constructed independently at different laboratories, was around 3 per cent.

An outstanding characteristic of the indicating circuits is complete objectivity, obtained by using biased thyratrons to operate neon bulbs which serve as "go, no-go" indicators. Fig. 2 is the schematic of the indicator circuits. It can be noted that two indicators are employed; the peak channel responds to the maximum voltage swing in the transient output of the tube, while the average channel provides for an integration of the output energy. The peak and average (integrated) values, together, most fully characterize the impulse-excited output of tubes. In the remainder of this discussion, only the peak channel will be of interest.

Full text of special article recommended by the AIEE Subcommittee on Electron Tubes of the Committee on Electronics.

R. J. Wohl is head of the Electron Physics Section, Material Laboratory, New York Naval Shipyard, Brooklyn, N. Y., and Stanley Winkler formerly a unit head in the same Section, is now chief, Operations Research Branch, Army Electronic Proving Ground, Fort Huachuca, Ariz.

The co-operation of M. Rosenberg and C. L. Rosenbaum of the Electron Physics Section in obtaining the data for this paper is hereby gratefully acknowledged.

Discrimination of the peak indicator between adjacent voltage values of the order of 0.5 per cent is readily achieved. The over-all repeatability of the complete equipment including the pendulum tapper, amplifier, and indicator was determined by repeated measurement of the output of a pickup excited by the pendulum tapper. The coefficient of variation so obtained was under 2 per cent.

It is interesting to note that this system for the measurement of audio-frequency impulse noise and microphonism has been approved by the Receiving Tube Subcommittee of the Armed Services Electron Tube Committee and is now being co-ordinated with industry for inclusion in *MIL-E-1B* Basic Specifications. A number of Service, university, and industry tube laboratories have contructed and are using the pendulum tapper and its associated equipment.

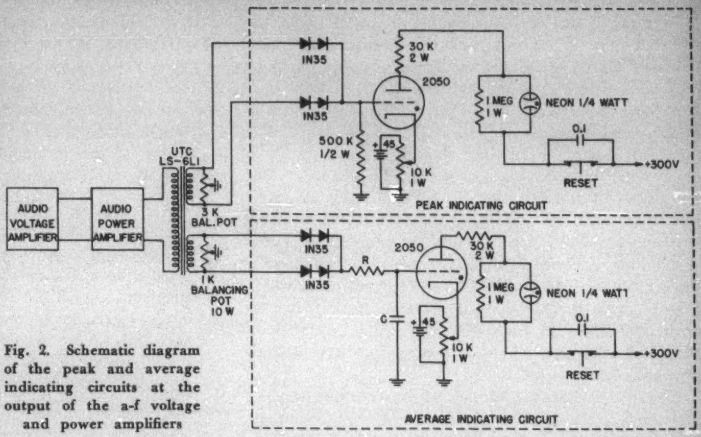


Fig. 2. Schematic diagram of the peak and average indicating circuits at the output of the a-f voltage and power amplifiers

SCREENING PROCEDURES AND RESULTS

THE repeatability and effectiveness of using the new system to select and reject (screen) on a "go, no-go" basis was investigated using 100 *6AK5W* electron tubes. These tubes were purchased on the open market. Each tube was struck three times in the direction of the maximum peak output with a 20-degree blow from the NML Standard Pendulum Tapper.

Peak outputs greater than given preset levels were indicated by the neon light. If the neon indicator was lit following any of the three blows, the particular electron tube under evaluation was classified as rejected. This is the criterion for rejection proposed for this system.

Six trials were made. For trials 1 and 2, 65 of the 100 tubes were chosen at random, and used to establish the rejection level. In trials 3, 4, 5, and 6, the entire sample was used and the amplifier gain was reduced 40 per cent. This reduction in gain was made to provide a more realistic rejection level since the shrinkage of 41 per cent obtained in trials 1 and 2 is exorbitant. Trials 1, 2, and 3 were performed by the same operator while trials 4, 5, and 6 were each performed by a different operator. Between trials, the circuit was recalibrated.

The results can be partially summarized in Table I:

Table I. Summary of Screening Tests

Trial	Number of Tubes	Relative Gain	Tubes Accepted	Tubes Rejected
1	65	1.0	37	28
2	65	1.0	39	26
3	100	0.6	85	15
4	100	0.6	82	18
5	100	0.6	86	14
6	100	0.6	82	18

An important aspect of the results of this screening investigation which is not revealed by Table I is the constancy of the distribution of these electron tubes into "pass" and "fail" categories. Since the investigation was carried out on a "go, no-go" basis, it is to be expected that some electron tubes would switch, on successive trials, from one category to another. The thyratron circuits employed are capable of discrimination within 0.1 volt. With a voltage rejection level at the thyratron of 20 volts, any increase greater than 0.5 per cent in the output of the tube under test is sufficient to change a borderline "go" to "no-go" indication. The high sensitivity of this evaluation, coupled with the normal variations in tube outputs, produces a so-called metastable or non-definitive region centering about the rejection level. If a given sample of electron tubes contained a large percentage of "switchers" on successive trials, it would be evidence either that the sample had a large percentage of tubes very close to the rejection level or that the sample possessed unusually high variability in tapped outputs.

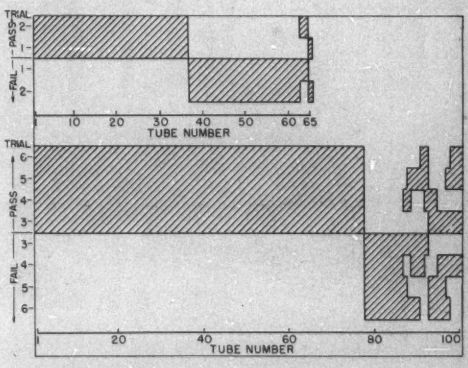


Fig. 3. The distribution of tubes into "pass" and "fail" categories

In trials 1 and 2, corresponding to higher gain, the distribution of 94 per cent of the tubes remained constant. Thus, of the 65 tubes in these trials, 62 tubes (36 pass, 26 fail) were the same on both trials. In trials 3, 4, 5, and 6 corresponding to lower gain, the distribution of 86 per cent (77 pass, 9 fail) remained constant. The apparent poorer repeatability of trials 3, 4, 5, and 6 in comparison with trials 1 and 2 is in accord with our previous observations that poor tubes are less repeatable. However, it is to be noted that the observations of any three of the operators in trials 3, 4, 5, and 6 were in agreement for the distribution of 95 per cent (81 pass, 14 fail) of the electron tubes evaluated. As might be expected, all tubes which passed during the high-gain trials were observed to pass during the low-gain trials. A graphical presentation of the distribution of the individual tubes into pass and fail categories is shown in Fig. 3.

A simple modification of the above procedures provides a method for the selection of electron tubes whose outputs are less than any preset value. This may be performed by the expedient of repeating the screening process and successively discarding rejected tubes prior to the next evaluation. When this was done with the lower gain on the 100 tubes utilized in these experiments, no additional failures occurred in all subsequent trials after the third. Thus, starting with 100 tubes, 15 tubes failed during the first trial, leaving 85 tubes for the second, during which 6 tubes failed. Of the 79 tubes in the third trial, only 2 tubes failed. The remaining 77 tubes passed three subsequent trials, meaning that the 77 passed tubes always had outputs less than the arbitrary rejection level. Since not one of these tubes, on three successive trials, produced excessive output, the increase in reliability, insofar as a-f impulse noise and microphonism is concerned, is obvious.

It should be noted that repetitive screening is not recommended for normal production use of these techniques. Also, the fact that only three trials were required to remove subnormal and ambiguous tubes attests to the high repeatability of the technique and the surprisingly good repeatability of the tubes for this parameter.

CONCLUSIONS

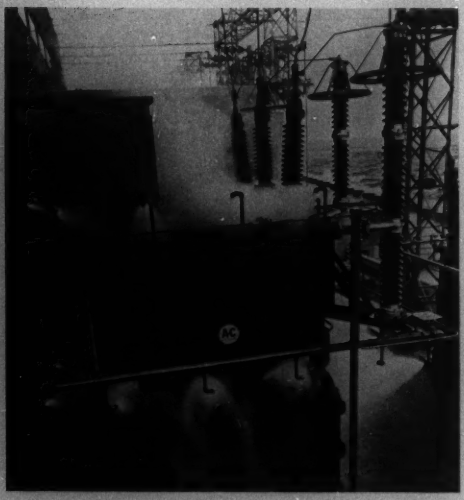
The techniques presented here for audio-frequency impulse noise and microphonism evaluations establish objective and repeatable criteria which enable reliable and effective screening of electron tubes. The comparative certainty with which undesirable tubes may be eliminated is in contra-distinction to other current methods, which depend upon a "statistical approach." By this is commonly meant that a 10-per cent rejection rate in one trial will be followed by a similar 10-per cent rejection rate in the second trial, with no assurance that the same tubes will be found in both rejection groups.

For normal applications, a single evaluation using the new procedures provides a highly satisfactory screening method. Repetitive screening of tubes may prove to be a valuable tool for applications where the highest reliability is required. In such cases, high shrinkage may be tolerated in return for the increase in reliability.

REFERENCE

1. Audio-Frequency Impulse Noise and Microphonism, **R. J. Wohl, S. Winkler, L. N. Heynick, M. Schnee.** Proceedings of the National Electronics Conference, vol. 9, p. 119, 1953.

Fire Protection System Guards Equipment



More than 2,200 gallons of water per minute shower from 90 nozzles in a test operation to check the efficiency of this water fog system. This modern fire protection system guards more than a half-million dollars worth of transmission equipment to ensure a continuing flow of power from the Eastlake power plant of The Cleveland Electric Illuminating Company. The transformers and circuit breakers contain over 14,000 gallons of combustible oil. The electric transformer group feeds power from one of the 140,000-kw turbogenerator units.

Pictured is unit number three of three identical water fog systems designed by the Sprinkler Division of Blaw-Knox Company, Pittsburgh, Pa., for the Eastlake plant. Water is released by any one of a series of rate-of-rise heat actuated devices which electrically open the deluge valve when the temperature rise is from 15 to 20 degrees F per minute. The system can be operated by switches in the turbine room, which is adjacent to the transformer deck.

The installation is surrounded by Lake Erie. Water from the lake is used in the fog system and is drawn from the station service water lines in which pressure is normally maintained at 175 psi.

Resistance Measurements of Energized A-C Windings

R. E. SEELY
MEMBER AIEE

A SIMPLE MEANS of measuring the electric resistance of a-c energized windings has long been desired, inasmuch as it would permit the determination of winding temperatures while the windings are operating under actual load conditions.

It will be realized that a Wheatstone bridge or ohmmeter cannot be used directly to measure the resistance of a-c energized windings because of two basic obstacles. First, the voltage would damage or burn out the bridge or ohmmeter. Secondly, even if it were possible to connect the bridge directly to a-c energized apparatus, it still would be impossible to measure the winding resistance since its resistance is paralleled by the resistances of all of the other loads on the line and by the resistance of the secondary winding of the supply transformer. The circuit, as shown in Fig. 1, permits such resistance measurements to be easily made using a bridge or ohmmeter on either single-phase or polyphase apparatus.

This circuit circumvents the two obstacles in the following manner. First, the voltage problem is surmounted by the use of a substantially equal and opposite bucking voltage as supplied by a potential transformer. One side of the potential-transformer secondary winding is connected to one side of the winding under test. This allows a bridge or ohmmeter to be connected to the other side of the winding on test and to the other side of the secondary of the potential transformer, since there is substantially zero voltage between these points. The necessary isolation of the winding under test, such that the direct current from the bridge or ohmmeter will not flow through the other paralleling resistances in the circuit, is accomplished by the use of banks of electrolytic capacitors between the windings and the paralleling resistances across the supply line. This permits the bridge to measure the sum of the resistances of the winding in question, the secondary of the transformer, and the leads. The actual winding resistance is then obtained by subtracting the resistance of the transformer and leads from the total resistance. The winding temperature

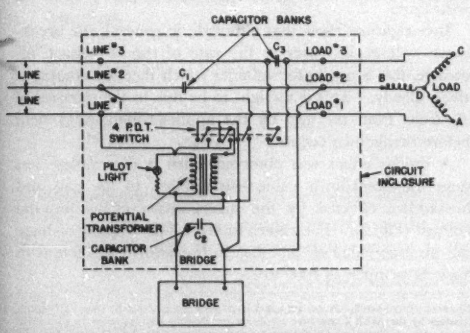


Fig. 1. Refined test circuit for measuring the resistance of a-c energized single-phase or polyphase windings

Fig. 2. The latest circuit enclosure for measuring resistance of a-c energized windings. The circuit is rated at 20 amperes, 250 volts, 60 cycles, single-phase or polyphase, 0.2 to 100 ohms

in degrees C can then be obtained by using the following equation

$$T_H = (R_H/R_C)(K+T_C) - K$$

where R_H is the hot winding resistance, R_C is the cold winding resistance at the start of the test, T_C is the cold winding temperature in degrees C as obtained by a thermometer at start of test, and K is a constant equal to 234.5 for copper windings and to 221 for aluminum windings. For winding temperatures in degrees F, these constants should be 390.1 for copper and 365.8 for aluminum.

Various sizes and ratings of this test circuit have been made since its conception 7 years ago. Fig. 2 shows one of the latest circuit boxes. This box has been rated at 20 amperes, 250 volts, 60 cycles, 1, 2, or 3 phase, 0.2 to 100 ohms resistance.

These circuits have been very useful pieces of test equipment for determining the winding temperature of induction motors. They have proved to be especially useful for testing hermetic refrigeration motors, since thermocouples cannot be readily used and since these motors cannot be shut down during test for a resistance reading without disrupting the test.

Digest of paper 55-23, "A Circuit for Measuring the Resistance of Energized A-C Windings," recommended by the AIEE Committee on Instruments and Measurements and approved by the AIEE Committee on Technical Operations for the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Communication and Electronics*, 1955.

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Protective Spark Gaps with Radioactive Substances

D. R. HARDY

IF a suitable voltage is applied to 2 electrodes, the gas between them may be made to break down and a time lag, which may vary considerably, will elapse between the application of voltage and the subsequent breakdown process. This time lag is attributed to the fact that the free electrons which initiate the breakdown process are produced at random by radioactive materials in the earth's crust or in the air, and by cosmic rays.

In certain circumstances where spark gaps are used for protective purposes or for the measurement of voltage, the time lag to breakdown may be excessive, and artificial means are adopted in order to produce free electrons more readily. Ultraviolet light produced by a mercury vapor lamp, or a corona or spark discharge may be used and the resulting irradiation of an electrode (usually the cathode) causes photoemission from the electrode surface. Such methods of irradiation are not always possible and the effectiveness of a given arrangement depends to a large extent on the condition of the surface of the electrode.

Radioactive substances are most effective irradiating agents. They have not been used extensively in the past mainly on account of their prohibitive cost, but in recent years with the increase in nuclear reactor plants they have become more readily available. They are easily applied, and produce an ionization which remains constant (or nearly so) for many years, and which is to a large extent independent of electrode condition.

The time lag to breakdown for a given degree of irradiation is also affected by the magnitude (as well as the time function) of the voltage applied. As the voltage is increased, the time lag decreases. This is illustrated in Fig. 1 which is for a 0.1-cm gap between two 2-cm-diameter brass spheres without irradiation, and with 0.1-cm gap and 0.03-cm gap respectively. The curves are constructed from a number of points which represent the average time lag for a particular overvoltage.

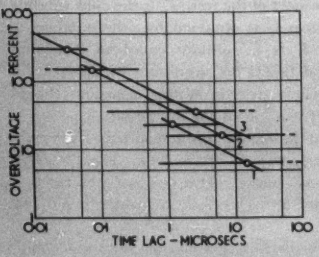

Fig. 1. Curve to show the range and average value of statistical time lag as a function of over-voltage. No irradiation. Curve 1. 1.0-cm gap, Curve 2. 0.1-cm gap, Curve 3. 0.03-cm gap

In order to assess the effectiveness of a given spark gap as a protective device it is necessary to know the variation or range of time lags about this average value. This is indicated in the figure by lines drawn through the average values, but in order to avoid overcrowding, typical ranges are shown only at the extremities of the time lag curves. Occasionally 1 or 2 lags may have been just too long or too short to measure accurately with the present apparatus, in which case the time spread line is shown in dotted form.

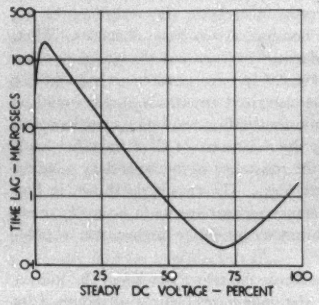

Fig. 2. Curve to show the average value of statistical time lag as a function of steady d-c voltage applied to 0.1-cm gap. Overvoltage 40 per cent. 1.0-mg. radium

For gaps greater than 0.3 cm, the introduction of a radioactive substance with an activity equivalent to that of 1.0 milligram radium ensures time lags to breakdown of less than 1 microsecond with overvoltages of only a few per cent. For smaller gaps the radioactive substance is not nearly as effective and overvoltages of 10 per cent (for a 0.1-cm gap) and upwards are required for the same time lag.

The most probable value of time lag for a given set of conditions may be predicted from a study of the distribution of time lags. These distributions depend on the time function of voltage; for example, breakdown is more likely with a rising voltage than with a voltage which decreases with time.

Investigations show that although, in general, the breakdown voltage increases as the rate of rise of voltage increases, this is not so for voltages which increase comparatively slowly. This is thought to be due to the removal of electrons from the gap by the applied (increasing) field before breakdown occurs.

A similar effect was observed when a d-c voltage less than the breakdown value was applied to the gap and breakdown effected by the superposition of an impulse voltage (Fig. 2). For a given total d-c plus impulse voltage the average value of time lag to breakdown was found to vary by as much as 1000 to 1.

Digest of paper 54-400, "Protective Spark Gaps with Radioactive Substances," recommended by the AIEE Committee on Protective Devices and approved by the AIEE Committee on Technical Operations for presentation at the Fall General Meeting, Chicago, Ill., October 11–15, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1954.

D. R. Hardy is with the University of Manchester, Manchester, England.

A Point-Contact Transistor Test Set

R. S. HILL

The objective in developing this point-contact transistor test set was to measure the important performance characteristics of point-contact transistors intended for use in large-signal applications of the pulse and switching circuit type. Its compact easy-to-use construction utilizes instruments readily available in any laboratory.

POINT - CONTACT transistors may be utilized in either small-signal or large-signal applications. When they are used in nonlinear applications such as switching circuits, their large-signal rather than their small-signal characteristics are of primary importance. In nonlinear applications, the operating point undergoes a large excursion—frequently from a low-current cutoff region (OFF condition), through an active region, to a high-current saturation region (ON condition). The measured parameters must describe the transistor throughout these three regions. It is with these large-signal characteristics that the test set described herein is concerned.

This point-contact transistor test set is a compact, portable unit capable of measuring the more important characteristics of point-contact transistors. It is ideally suited for use in transistor application laboratories where an oscilloscope, a pulse generator, and a vacuum tube voltmeter are available as complementary instruments. Except for these generally available equipments, this test set is entirely self-contained. For this reason, it represents an economical balance between self-sufficiency and practicality.

The following measurements can be rapidly and accurately made with this instrument:

Direct-Current:

1. $r_B(V_B, I_C)$ reverse resistance of the cutoff emitter with $I_C = 0$ ma
2A. $r_C(I_E, V_C)$ reverse resistance of the cutoff collector with $I_E = 0$ ma
2B. $I_C(I_E, V_C)$ collector current with $I_E = 0$ ma
3. $r_B(I_E, V_C)$ base resistance with $I_E = 0$ ma
4. α_{av} average alpha over a specified increment of I_E
5. $V_C(I_E, I_C)$ collector saturation voltage with: $I_E = +3$ ma, and $I_C = -4$ ma

Static:

6. V_C vs I_C family with I_E as parameter

Dynamic:

7. Frequency response:
   - A. Rise time
   - B. Fall time
   - C. Ohmic delay
   - D. Storage time

The d-c parameters are measured by applying the specified d-c bias voltages to the appropriate elements of the transistor. The resultant current is shown directly on the meter. The desired parameter may be either read directly or determined by a simple arithmetic calculation.

The static collector family is displayed on the oscilloscope screen. A sweep voltage is applied to the collector while the emitter current is adjusted in specified incremental steps. The V_C vs I_C display may be photographed on the cathode-ray tube if desired.

In order to display the frequency response characteristics (i.e., rise time, fall time, ohmic delay, storage time), an isolated subpanel assembly is employed to insure a minimum of high-frequency distortion. Again in this case, the desired information is revealed as a display on the oscilloscope screen which may be photographed if desired.

Maximum operating efficiency is assured by switching operations which automatically commutate the power supplies, effect the necessary circuit changes, etc., as required for the desired measurements. Potentiometers are included to facilitate the adjustment of voltages and currents. Each individual circuit is so designed that the possibility of damaging the transistor is eliminated. Appropriate socket connections are available to accommodate all existing types of point-contact transistors.

The front panel face of the test set is shown in Fig. 1. Fig. 2 is an internal view. Figs. 3 and 4 are schematic diagrams of the electric circuitry.

A detailed description by Wooley of the measurements which the present instrument is capable of making, as well as a general discussion of testing methods, already has been published.

OPERATING INSTRUCTIONS

BEFORE any switching operation, turn all potentiometers to zero position. All toggle switches are OFF in the downwards position.

1. Operation: OFF
   Rotary switch position: 1
   All toggle switches: OFF
2. Operation: Measure $r_B(V_B, I_C)$ with $I_C = 0$ ma
   Rotary switch position: 3
   "Power" switch ON; all others OFF
   With the voltmeter at V_B adjust $V_B ADJ$ until $V_B = -10$ volts

   Read I_B then $r_B = \dfrac{V_B}{I_B}$

For this operation, the emitter resistance in the reverse direction is measured with the collector open. A bias of

The last of a series of three special articles on point-contact transistors appearing in *Electrical Engineering*. The first by R. L. Wooley entitled "Testing Point-Contact Transistors for Pulse Applications" appeared in the November 1954 issue, pp. 981–7; the second by T. P. Sylvan entitled "An Alpha Plotter for Point-Contact Transistors" appeared in the December 1954 issue, pp. 1094–8.

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For an explanation of the symbolic terminology see footnote on p. 981 of the Wooley article.

Fig. 1. Point-contact transistor test set

Fig. 2. Point-contact transistor test set, internal view

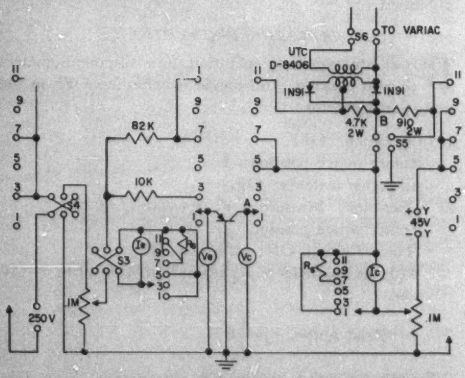


Fig. 3. Point-contact transistor test set, schematic diagram

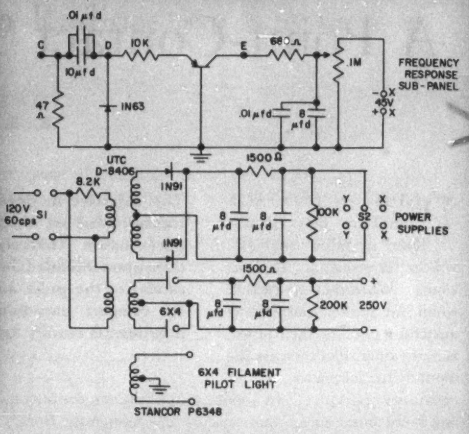


Fig. 4. Point-contact transistor test set subassemblies, schematic diagram

-10 volts is applied to the emitter and the resultant current is observed, from which the emitter resistance is calculated. See Fig. 5.

3. Operation: Measure $I_C(I_E, V_C)$, $r_B(I_E, V_C)$, $r_C(I_E, V_C)$ with $I_E=0$
   Rotary switch position: 5
   "Power" switch ON; "Reverse" switches ON; others OFF
   With voltmeter at V_C, adjust V_CADJ until $V_C=-15$ volts
   Read I_C and V_E, then $r_B=V_E/I_C$ and $r_C=V_C/I_C$

For this operation, the collector current, the base resistance, and the collector resistance are all measured with the emitter open. A bias of -15 volts is applied to the collector and the resultant current is observed. The voltage appearing on the emitter is also observed. Resistances are then calculated. Refer to Fig. 6.

4. Operation: Measure α_{av}
   Rotary switch position: 7
   "Power" switch ON; "Reverse" switches ON; all others OFF
   Adjust V_EADJ until $I_E=+1$ ma; adjust V_CADJ until $V_C=-15$ volts
   Read (full scale = 5 ma) $I_C(1, V_C)$ then $\alpha_{av}=I_C(1, V_C)-I_C(0, V_C)$

For this operation, the current gain factor is measured. In this instance, the current gain factor is the average value over the range between values of 0 and 1 ma for emitter current. See Fig. 7.

$$\alpha=\frac{\partial I_C}{\partial I_E}\Big|V_C \text{ const}$$

$$\alpha_{av}=\frac{\Delta I_C}{\Delta I_E}\Big|V_C \text{ const}$$

$$=\frac{I_C(1, V_C)-I_C(0, V_C)}{1 \text{ ma}-0 \text{ ma}}$$

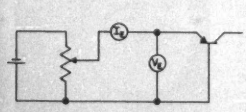
5. Operation: Measure $V_C(I_E, I_C)$ with $I_E = +3$ ma and $I_C = -4$ ma
   Rotary switch position: 7
   "Power" switch ON; "Reverse" switches ON; all others OFF
   Adjust $V_E ADJ$ until $I_E = +3$ ma; adjust $V_C ADJ$ until $I_C = -4$ ma
   Read $V_C(3, 4)$

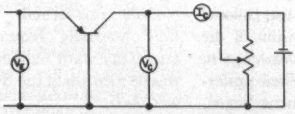
For this operation, the collector voltage is measured when the emitter current is 3 ma and the collector current is -4 ma. This measurement is an indication of the proximity of the saturation line to the axis. (See Fig. 9.) The circuit involved here is the same as that of Fig. 7.

6. Operation: Calibration of DuMont oscilloscope
   Rotary switch position: "Power" switch ON; "Reverse" switches ON; "Cal" switch ON; and all the other switches OFF.
   Adjust $V_C ADJ$ until $I_C = 2$ ma. This current is now flowing through the "current-measuring resistor." Using the voltage at the I_C receptacle, calibrate the gain of the X channel. Adjust $V_C ADJ$ until $V_C = 10$ volts. Using the voltage at the I_C receptacle, calibrate the gain of the Y channel. Standard calibrations for this operation are 2 ma = 1 inch on X channel and 10 volts = 1 inch on Y channel

Table I. Operating Instructions

Parameter to Be Measured	Rotary Switch	"Power" Switch S_1	"Select" Switch S_2	"Reverse" Switches S_3 and S_4	"Cal" Switch S_5	"Sweep" Switch S_6	
OFF	1	off	off	off	off	off	Test Set Off
$r_B(V_B, I_C)$	3	on	off	off	off	off	Set $V_B = -10$ volts Read I_B $r_B = V_B/I_B$
$I_C(I_B, V_C)$	5	on	off	on	off	off	Set $V_C = -15$ volts Read $I_C(0, V_C)$ and V_B $r_B = V_B/I_C$
$r_B(I_B, V_C)$							
$r_C(I_B, V_C)$							$r_C = V_C/I_C$
α_{AV}	7	on	off	on	off	off	Set $V_C = -15$ volts, $I_B = 1$ ma Read $I_C(1, V_C)$ Full scale = 5ma $\alpha_{AV} = I_C(1, V_C) - I_C(0, V_C)$
$V_C(I_B, I_C)$	7	on	off	on	off	off	Set $I_B = 3$ ma and $I_C = -4$ ma Read $V_C(3, 4)$ Full scale = 5 ma
Calibrate 'Scope	9	on	off Use DuMont Scope	on	on	off	Voltmeter to I_C receptacle Set current to 2 ma Adjust gain X channel Set voltage to 10 volts Adjust gain Y channel
V_C vs I_C	11	on	off Use DuMont Scope	on	off	on	X lead to I_C Y lead to V_C Adjust sweeper voltage Set $I_B = 0, 0.5, -2.5$ ma
Frequency response	1	on	on Use Tektronix Scope and subpanel	off	off	off	Voltmeter to I_C receptacle Adjust $V_C = -15$ volts remove meter Pulse input to "IN" Probe at I_B receptacle Observe input pulse Probe at I_C receptacle Observe t_D, t_f, t_o, t_s





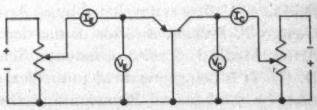
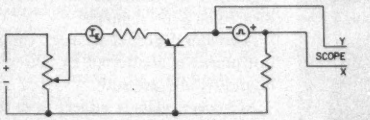


Fig. 5 (left). Circuit for measurement of emitter resistance. Fig. 6 (center). Circuit for measurement of collector current, base resistance, and collector resistance. Fig. 7 (right). Circuit for the measurement of average alpha



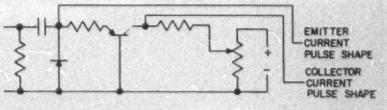
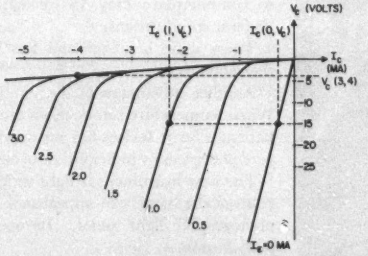


Fig. 8 (left). Circuit for display of V_C vs. I_C curve family. Fig. 10 (right). Circuit for measurement of frequency response



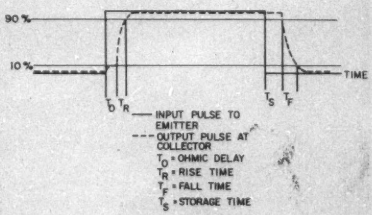


Fig. 9 (left). Typical V_C versus I_C characteristic family for a point-contact transistor. Fig. 11 (right). Typical frequency response for a point-contact transistor

7. Operation: V_c vs. I_c characteristic family
Rotary switch position: 11
"Power" switch ON; "Reverse" switches ON; "Sweep" switch ON; all others OFF. X lead to I_c receptacle. Y lead to V_c receptacle.
Adjust sweeper voltage with the variac until the peak sweep voltage is approximately 20 volts. The emitter is set at increments of 0.5 ma between 0 and 2.5 ma to produce the family of curves. Photographs may be taken as required.

For this operation, the static collector characteristic family is displayed on the oscilloscope screen. This family is a plot of V_c vs I_c for constant incremental values of emitter current. See Figs. 8 and 9.

8. Operation: Frequency response by pulse method
Rotary switch position: 1
"Power" switch ON; "Select" switch ON; All others OFF
Subpanel assembly and Tektronix Scope used exclusively in this operation.
With voltmeter at I_c receptable, adjust V_cADJ until $V_c = -15$ volts
Pulse input at "in" adjusted to 10-volt positive pulse
Probe at I_s reveals shape of emitter current pulse
Probe at I_c reveals shape of collector current pulse.

Ohmic delay is the time between the application of the input pulse and the time when the output pulse attains 10 per cent of its final maximum amplitude. *Rise time* is the time duration during which the output pulse is increasing from 10 to 90 per cent of its maximum average amplitude. *Storage time* is the time between the end of the input pulse and the time when the output pulse has decreased to 90 per cent of its maximum average amplitude. *Fall time* is the time duration during which the output is decreasing from 90 to 10 per cent of its maximum average value. These time intervals are illustrated in Fig. 11. Photographs may be taken as required.

This operation reveals characteristics which affect the high-frequency or switching speed limitations of the transistor. See Figs. 10 and 11.

Electronic Thermometer Is Developed by Army Dentist

An electronic clinical thermometer that takes your temperature in 5 seconds, which is less time than it takes to shake down the mercury in the glass-rod thermometer, was recently announced in the *Army News Features*. The new thermometer, the "Swiftem," the first innovation in the field since 1867, was developed by an Army dentist, Colonel George T. Perkins, director of the dental division of the Army Medical Service Graduate School, Washington, D. C. It is being presented to medical and allied professions by the Medical Research and Development Board, U. S. Army.

How much time and manpower can be saved by such a quick-reading thermometer was demonstrated during a 4-month test in an Army hospital.

Only one-fortieth of the time normally required to take daily ward temperatures was needed when the Swiftem was used.

There are additional advantages. The electronic thermometer is much easier to read, since degrees are registered in numerals on a meter just as speeds are indicated on a speedometer.

A greater degree of accuracy can be obtained, for the new instrument is unaffected by extreme temperature changes, humidity, and pressure.

Moreover, glass is subject to so many kinds of structural change that of 75 conventional thermometers checked during tests only 25 proved accurate. These inaccuracies are so commonplace they are recognized and permitted by Federal specifications.

There is no breakage and less loss with the electronic thermometer.

Another advantage is the elimination of malingering. When temperature can be taken almost instantaneously, the patient who is faking has no opportunity to raise the recorded degrees by judicious use of cigarette lighter or match.

The new instrument is light-weight and fits easily in the palm of the hand. In appearance and size, it resembles a photographic light meter. Its operation is controlled by push-button.

Evaluation of Power Factor Correction on a System Basis

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MEMBER AIEE

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IN planning future load capabilities for a system having integrated transmission and distribution facilities, it is important that the economic limits be known for supplying the system's reactive loads with shunt capacitors. In the majority of the many cases[1,2] dealing with the economics of capacitor application, treatment is made of only the resulting benefits to a particular portion of the system, or to a particular item of system costs, such as the savings in losses. A true evaluation of load power factor correction should, however, include all the simultaneously resulting benefits from the location of the capacitor back to the alternate source of reactive supply. The over-all benefits should be appraised on the basis of:

1. Costs for facilities to generate with synchronous equipment, transmit, and distribute reactive loads.
2. Costs for compensation of voltage regulation caused by the transmission and distribution of reactive loads.
3. Costs for losses.
4. Costs incurred because of changes in system stability limits.

For a large system, this may appear to be a formidable task. However, it may be simplified by representing each major element of the system by an equivalent circuit with typical electrical and cost characteristics from which calculations can be made to determine voltage regulation, losses, and required investments. A step process can then be employed to sum the cost components in all the system elements to provide firm capacity for a kilowatt of load at any stated power factor.

In a study made for a large Eastern utility, the system was divided into four major elements; namely, distribution, subtransmission, transmission, and that portion of the generating facilities required to supply kilovars only. An analytical survey was made of each element to an extent necessary to represent its performance in the system as an electric impedance and to determine its investment cost per kva of load for a firm supply.

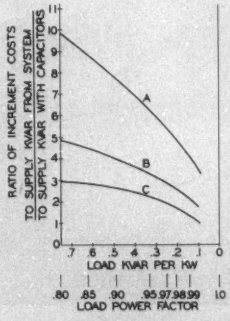

Fig. 1. Ratio of increment costs, including investments and capitalized losses, in supplying kilovars from generation to supplying kilovars with capacitors. (A) For load at center of distribution, (B) for load at substations on the subtransmission system, (C) for load at substations on the transmission system

If the summation of costs derived for a kilowatt of distribution load at unity power factor is taken as 100 per cent, then the costs for a kilowatt of load at lagging power factors are:

Power Factor	80	85	90	95	97	99	100
Per Cent Cost	156	142	128	116	110	105	100

Thus the cost to distribute at 80 per cent power factor is 56 per cent the cost for the kilowatt load.

The installation of capacitors at or near the load serves to reduce these costs in a number of ways. In the typical case it was found that, on the distribution circuits to the centers of distribution, permissible loadings were largely established by thermal limits. The benefits of improved power factor at these locations were to permit distribution of more kw through these facilities at the same current loading and with the same losses, which reduces both investment and losses per kilowatt of load. On the subtransmission and transmission systems, maximum loadings were generally found to be determined by voltage limits. In these cases an improvement in power factor reduces investment per kilowatt even more than in the thermally limited case but at a slight increase in losses per kilowatt.

The ratio of the costs to supply kilovars from the system to the cost for supplying kilovars with capacitors is shown in Fig. 1. The curves *A*, *B*, and *C* are for reactive loads on the distribution, subtransmission, and transmission systems, respectively. Since a ratio greater than 1 is favorable to a capacitor installation, the conclusions are made that the economic limit for supplying reactive loads with capacitors approaches 100 per cent. It is further concluded from the relative position of curves, *A*, *B*, and *C* that the greatest benefits from capacitors can be derived when installations are made as close to reactive loads as possible.

An analysis made for stability limits with unit power factor transmission indicates that for systems having power sources interconnected through a closely-knit transmission system, it is unusual that the adverse effects of high power factor transmission will impose any stability limits on transmission capabilities before thermal and/or voltage limitations become effective.

REFERENCES

1. Bibliography on Power Capacitors 1925–1950, AIEE *Special Publication S-43*, January 1952.

2. Bibliography on Power Capacitors 1950–1952, AIEE Committee Report, AIEE *Transactions*, vol. 72, pt. III, 1953, pp. 136–9.

3. Underexcited Operation of Turbogenerators by C. G. Adams, J. B. McClure, AIEE *Transactions*, vol. 67, 1949, pp. 521–6.

Digest of paper 54-385, "Evaluation of Power Factor Correction on a System Basis," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 11–15, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1955.

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Measurements of Materials at Ultrahigh Frequencies

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ASSOCIATE MEMBER

THE best ways to measure the dielectric properties of materials with high dielectric constant are described throughout the frequency range from 100 to 1,000 mc. The principles of measurement of dielectric properties at ultrahigh frequencies are well established. They are based on measurement of voltage standing wave ratio and location of standing wave pattern, which results from reflection of electromagnetic energy from the dielectric sample. If the sample fills part of the transmission line in the form of a slab, with boundaries parallel to the field, the observable quantities W (inverse of the voltage standing wave ratio) and $l=x_o-\lambda/4$ (x_o distance of minimum of voltage from sample boundary) are related directly to the dielectric properties. For the two most important cases, sample loaded with either infinite or zero impedance, these relations hold

$$\sqrt{\epsilon^+}\tan[2\pi d/\lambda\sqrt{\epsilon^+}] = \tan L_1 \quad \text{(sample load } \infty\text{)}$$

$$\frac{1}{\sqrt{\epsilon^+}}\tan\left[\frac{2\pi d}{\lambda}\sqrt{\epsilon^+}\right] = \tan L_2 \text{ (sample load 0)}$$

where ϵ^+-complex dielectric constant, and $L_{1,2}=(2\pi l/\lambda)-j\tanh^{-1}W$. Fig. 1 shows the variation of the quantity l in parts of $\lambda/4$, characterizing the shift in phase pattern, when the open- or short-circuit terminal of the transmission line is replaced by open- or short-circuited sample. It is plotted as a function of sample thickness for both open- and short-circuited cases for a dielectric constant with a permittivity of 60 and an electric conductivity of 0.01 ohm^{-1}cm^{-1}. These values are characteristic for many tissues. The maximum l obtainable with the short-circuit technique is in most cases considerably smaller than 1 cm. Therefore, accurate values of l are difficult to obtain. The open circuit technique gives values of l which are near $\lambda/4$ for sample thickness values greater than 1 cm. This will yield operating conditions with high sensitiveness of tan L_1 to its argument. Suitable l-values exist only for d-values of 1 to 2 mm. In Fig. 2 the inverse of voltage standing wave ratio is plotted against d. In the open load case, W-values near 0.1 are obtained, while in the short-circuit case W varies rapidly with d and approaches values of less than 0.001. Such values are difficult to measure since they compare with those due to losses of the transmission line itself. If the thickness of the sample is very big, or if the sample is loaded with its own characteristic impedance, again simple equations are obtained. It can be shown that accurate results for the permittivity may be obtained in this case, but that it is practically impossible to measure the loss tangent. The foregoing discussion proves, therefore, that small sample thickness and open-circuit techniques provide the only feasible possibility for determining dielectric properties of material of high dielectric constant in the frequency range from 100 to 1000 mc.

For small sample thickness, the determination of the dielectric parameters from l and W is carried out most simply with the help of the equations

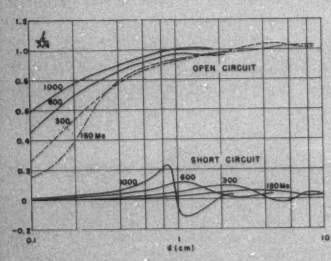
$$(2\pi d/\lambda)\epsilon = \tan 2\pi l/\lambda[1-W^2/1+W^2\tan^2(2\pi l/\lambda)]$$

$$2\pi d/\lambda(\epsilon\tan\delta) = W[1+\tan^2(2\pi l/\lambda)]/[1+W^2\tan^2(2\pi l/\lambda)]$$

These equations are approximations whose error is usually small and approximately characterized by the expressions

$$\Delta\epsilon/\epsilon = 1/3(2\pi d/\lambda)^2\epsilon(1-\tan^2\delta);\quad \Delta(\epsilon\tan\delta)/\epsilon\tan\delta = 2/3(2\pi d/\lambda)^2\epsilon$$

In view of the desirability of small sample thickness, it is found advantageous that the sample holder be constructed in a manner which does not effect the field pattern in the sample itself. That is, the sample holder plates are insulating plates which contact the transmission line conductors without any change in the dimensions of these conductors. In this case, the sample holder establishes a capacitive load in itself which can be corrected by simple techniques. Accuracy in determinations permittivity ϵ and loss tangent tan δ can be quite high under these circumstances and is found theoretically to be about 1 per cent for the relative accuracy of $\epsilon\tan\delta$ and about (tan δ) per cent for the relative accuracy of permittivity ϵ.



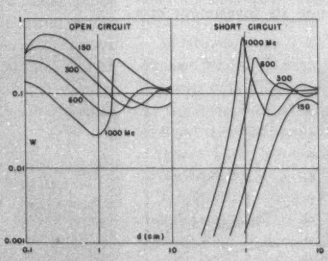


Fig. 1 (left). Phase constant l as a function of sample thickness and frequency for open- and short-circuited sample case (permittivity of sample 60, conductivity 0.01 ohm^{-1} cm^{-1}). Fig. 2 (right). Inverse of voltage standing wave ratio ($1/W$) as function of sample thickness and frequency for sample case as in Fig. 1

Digest of paper 54-524 "Measurements of Materials with High Dielectric Constant and Conductivity at Ultrahigh Frequencies," recommended by the AIEE Committee on Electrical Techniques in Medicine and Biology and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 11-15, 1954. Scheduled for publication in AIEE *Communication and Electronics*, 1954.

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INSTITUTE ACTIVITIES

One of the Largest AIEE Technical Programs to Be Offered at Winter General Meeting

The AIEE Winter General Meeting to be held at the Hotels Statler and Governor Clinton in New York, N. Y., January 31–February 4, 1955, will feature one of the largest technical programs in the history of the Institute. The social activities, for which the Winter General Meeting also is known, again will be one of the outstanding features. A group of varied and interesting inspection trips has been arranged, too, closely allied with the technical sessions.

GENERAL SESSION

At the General Session on Monday, January 31 at 2:30 p.m., Brig. General David Sarnoff, chairman of the board, Radio Corporation of America, will give the principal address. Just prior to General Sarnoff's remarks, the John Scott Medal will be presented to Dr. Marvin Camras, senior physicist at the Armour Research Foundation of the Illinois Institute of Technology. At this same meeting the Institute prizes for papers will be awarded. President A. C. Monteith will open the session with his report to the membership.

At a special session Tuesday, 1:45 p.m., the John Fritz Medal will be presented to Mr. Harry A. Winne, vice-president of the General Electric Company. On Wednesday, at the same hour, Dr. Oliver E. Buckley, president of the Bell Telephone Laboratories, will receive the Edison Medal. The public is cordially invited to these three sessions.

TECHNICAL SESSIONS

Over 480 papers will be presented in some 90 technical sessions ranging through five broad fields of institute technical activities—science and electronics, communication, power, general applications, and industry. In addition, sessions will be sponsored by general committees in the fields of safety, ethics, management, education, and research.

Among the 30-odd sessions of the power division, two sessions on synchronous machines to be held on Wednesday will be devoted to the general subject of operation and maintenance of turbine generators, with papers presented by both manufacturers and operators. A working group of the Synchronous Machinery Subcommittee has prepared guides for the operation and maintenance of turbine generators and it is hoped that this group of papers and the discussions will bring out considerable information for finalizing the guides.

Under the sponsorship of the Committee on Research, an important symposium will explore the question, "How can the utilities best make use of modern science?" Prominent authors in the field of research will outline the implementation of a research program from the point of view of university and research foundation facilities. Other well known authors will present the point of view of the utilities, the role of the manufacturer, and the most modern thinking and trends in educational circles which will be of great interest to all educational people, utility executives, and research men.

INFORMAL TEA

This social gathering before the formal program begins has been enjoyed by more people each year. Make it a point to attend this year on Sunday afternoon, January 30, from 4:00 to 6:00 p.m. in the Georgian Room of the Statler. There will be no charge.

During this period, registration facilities will be open for those who want to avoid the Monday morning rush.

At right is night view of the Hazel blast furnace and cast house at U. S. Steel's Fairless Works near Morrisville, Pa. AIEE members attending the 1955 Winter General Meeting in New York City this month will be able to see the Fairless Works as it is one of the many inspection trips of general and technical interest that have been arranged

Future AIEE Meetings

AIEE-IRE-NBS High-Frequency Measurements Conference
Hotel Statler, Washington, D. C.
January 17–19, 1955
(*Final date for submitting papers—closed*)

Winter General Meeting
Hotels Statler and Governor Clinton, New York, N. Y.
January 31–February 4, 1955
(*Final date for submitting papers—closed*)

AIEE-IRE Transistor Circuits Conference
University of Pennsylvania, Philadelphia, Pa.
February 17–18, 1955
(*Final date for submitting papers—closed*)

AIEE-IRE-ACM Western Computer Conference
Hotel Statler, Los Angeles, Calif.
March 1–3, 1955
(*Final date for submitting papers—closed*)

Electrical Utilization of Aluminum Conference
William Penn Hotel, Pittsburgh, Pa.
March 15–17, 1955
(*Final date for submitting papers—closed*)

Materials Handling Conference
Hotel Cleveland, Cleveland, Ohio
March 28–29, 1955
(*Final date for submitting papers—closed*)

Rubber and Plastics Conference
Akron, Ohio
April 4–5, 1955
(*Final date for submitting papers—January 5*)

Southern District Meeting
St. Petersburg, Fla.
April 13–15, 1955
(*Final date for submitting papers—January 12*)

Pulp and Paper Conference
St. Petersburg, Fla.
April 14, 1955
(*Final date for submitting papers—January 14*)

Middle Eastern District Meeting
Columbus, Ohio
May 4–6, 1955
(*Final date for submitting papers—February 4*)

Electric Heating Conference
LaSalle Hotel, Chicago, Ill.
May 10–11, 1955
(*Final date for submitting papers—February 10*)

AIEE-IAS-IRE-ISA Conference on Telemetering
Morrison Hotel, Chicago, Ill.
May 18–20, 1955
(*Final date for submitting papers—February 18*)

AIEE-APS-AIME-CIT Conference on Magnetism and Magnetic Materials
William Penn Hotel, Pittsburgh, Pa.
June 14–16, 1955
(*Final date for submitting papers—March 14*)

1955 Summer General Meeting
New Ocean House, Swampscott, Mass.
June 27–July 1, 1955
(*Final date for submitting papers—March 29*)

Members will travel across the Hudson River to Edgewater, N. J., to tour the Ford Automobile Company's assembly plant as one of the Winter Meeting Inspection trips

HOTEL RESERVATIONS

Blocks of rooms have been set aside at the Statler and nearby hotels for members and guests attending the meeting. Requests for reservations should be sent, prior to January 17, directly to the hotel of choice and to only one hotel. AIEE should be mentioned in the request. If rooms are not available at the hotel of your choice, your request will be referred to the Hotel Accommodations Committee. This committee will then place it with another convention hotel.

Because of the current accommodations situation in New York, reservations for arrival on Sunday, January 30, are suggested.

Hotel Statler (meeting Headquarters), 7th Avenue, 32d to 33d Streets	
Single room with bath	$ 6.50 to $11.00
Double room	9.50 to 14.00
Twin Bedroom	10.50 to 18.00
Suites	28.00 to 30.00
Hotel New Yorker, 34th Street and 8th Avenue	
Single room with bath	$ 6.00 to $12.00
Double room	9.00 to 14.50
Twin bedroom	10.50 to 16.00
Hotel Governor Clinton, 7th Avenue at 31st Street	
Single room with bath	$ 6.00 to $ 9.00
Double room	8.50 to 11.50
Twin bedroom	10.50 to 14.50
Hotel McAlpin, Broadway and 34th Street	
Single room with bath	$ 4.50 to $ 9.25
Double room	7.00 to 13.50
Twin bedroom	8.50 to 13.50
Hotel Roosevelt, Madison Avenue at 45th Street	
Single room with bath	$ 7.50 to $14.00
Double room	12.50 to 17.50
Twin bedroom	15.00 to 20.00
Hotel Martinique, Broadway and 32nd Street	
Single room with bath	$ 5.00 to $ 7.00
Double room	8.50 to 11.00
Twin bedroom	9.00 to 12.00

Rates are subject to 5 per cent New York City hotel room tax.

SMOKER COMMITTEE

A smoker is scheduled for Tuesday evening, February 1. Attention is called to the fact that the smoker will be held at the Hotel Statler, rather than at the Hotel Commodore as in recent years. Tickets will be $10.00 each. Make checks payable to "Special Account, Secretary AIEE." Reservations should be made at an early date and addressed to: Smoker Committee, AIEE Headquarters, 33 West 39th Street, New York 18, N. Y. Reservations received after January 11 will not be honored.

DINNER-DANCE

The Dinner-Dance, climax of the social affairs planned for the Winter General Meeting, is scheduled for Thursday, February 3, 1955, at 7:00 p.m. in the Grand Ballroom, Hotel Statler, New York. Music will be by Charles Peterson and the food will be better than ever. Reserve your place, or tables for ten, now by calling or writing to Dinner-Dance Committee, AIEE Headquarters, 33 West 39th Street, New York. Tickets are $12.00 each, and checks should be made payable to "Special Account, Secretary AIEE."

INSPECTION TRIPS

A program of inspection trips of both technical and general interest has been arranged for those attending the Winter General Meeting. Since the number of people who can be accommodated on these trips is limited, members who are interested are urged to make arrangements at the Inspection Trips Desk immediately after registering.

Radio City Music Hall, New York, N. Y. (*Tuesday morning, February 1*). This ever-popular trip has been scheduled again. Spectacular stage shows distinguished by unique lighting effects have made the Radio City Music Hall an outstanding attraction for visitors from all over the world. Members will see the backstage facilities as well as unusual features, such as the revolving sectionalized stage, elevating orchestra pit, motorized curtains and the multitude of electrical and mechanical controls required for the special stage and lighting effects.

Astoria Generating Station, Astoria, N. Y. (*Tuesday morning and afternoon, February 1*). This modern and completely new indoor generating plant of the Consolidated Edison Company of New York, Inc., is a "unit system" installation located in the borough of Queens. There are two 13-story high boilers to provide high-pressure steam for the two 180,000 kw cross-compound turbine generators. The boilers are equipped to burn coal, oil and natural gas. The company's latest steps toward automatic controls and instrumentation should prove interesting. All elements for the supervision and the control of the major equipment for the generator units are centralized. (U. S. citizens only.)

International Business Machines Corporation (*IBM*), *New York, N. Y.* (*Tuesday morning, February 1, Wednesday afternoon, February 2, and Friday morning, February 4*). IBM's Type-701 Electronic Data Processing Machine, which is one of the world's fastest and most versatile computers, will be demonstrated. This installation is part of IBM's scientific computing service. It is in daily use for solving problems for American Industry. The calculator and other outstanding developments in this field will be explained and some of the many applications will be described.

New York Stock Exchange, (*Tuesday afternoon, February 1, Wednesday morning, February 2, and Thursday morning, February 3*). Arrangements have been made to permit a limited number of persons to visit the famous New York Stock Exchange. A talk on the Exchange's function in the economic welfare of the nation will be followed by a technicolor movie entitled, "What Makes Us Tick." In addition, visitors will be allowed to watch activities on the floor of the Exchange from the gallery.

United Nations, New York, N. Y. (*Tuesday afternoon, February 1*). This trip will include the regular guided tour and will be preceded by a talk on the electrical equipment by a representative of the consulting engineers who worked on the design of the buildings. Many unusual features are to be seen, such as unique lighting effects and special acoustical treatments. A complex communication system enables listeners to hear a speech as it is being delivered in any one of five languages by a twist of a dial.

Fairless Steel Plant, Fairless, Pa. (*Wednesday, All Day*). The Fairless Works is U. S. Steel's first integrated steel plant in the East and covers 3,000 acres of land near Trenton, N. J., of which 175 are under roof. The inspection party will see all of the operations including the stock pile of raw materials (iron ore, coal and limestone) the blast furnaces, open hearth plant, the hot strip mill, and the sheet and tin finishing mills.

This plant has an annual capacity of ap-

proximately 1,200,000 tons of pig iron which, when used in the plant's nine open hearth furnaces, furnish 1,800,000 tons of steel. The large amount of electric equipment used for driving and controlling various operations in the mills will also be of interest to our members.

Rambusch Decorating Company, New York, N. Y. (Wednesday afternoon, February 2). Founded in 1890, the Rambusch Decorating Company has progressed from its original field of church painting to its present status as an outstanding specialist in the design and manufacture of ornamental and engineered lighting equipment. Here members will find under one roof such diversified crafts as mural painting, sculpture, stained-glass-window design, cabinet making and metal shops, as well as those involved in the production of special lighting fixtures. This should prove to be an unusual experience to members with artistic interests.

Sylvania Research Laboratories, Bayside, N. Y. (Wednesday afternoon, February 2). A visit to the physics laboratory will be undertaken where much of the basic research for Sylvania products is done. Visitors will be conducted through the following areas in small groups: research areas devoted to luminescence, color television, travelling wave tubes, semiconductors, mass spectrometry, as well as engineering service areas as provided by the glass shop and machine shop.

Brookhaven National Laboratory, Upton, N. Y. (Thursday, All Day). The facilities at this location are operated by Associated Universities, Inc., under contract with the Atomic Energy Commission, and constitute the Northeastern Center for nuclear research and development in the fields of physics, chemistry, biology, medicine, and engineering. Among the important exhibits that our members will see are the atomic pile, the cloud chamber, the cosmotron and the hot laboratory. A complete tour has been arranged in great detail and competent guides, engineers, and scientists will be on hand to explain the extensive facilities and exhibits which have been erected. Members must sign for this trip before 4:30 p.m. February 1, 1955. (U.S. citizens only.)

Ford Assembly Plant, Edgewater, N. J. (Thursday morning, February 3). This plant offers a good opportunity to see all the interesting detail work that goes into the assembly of an automobile. On 961,000 square feet of floor space, 45 freight carloads of auto parts are converted daily by 2,800 employees, using 10 miles of conveyor lines and a 1,025-foot final car-assembly line, into completed cars and trucks. The 36-acre site of the plant includes the main assembly, steam power plant, and oil house.

Westinghouse Television Center, Metuchen, N. J. (Thursday morning, February 3). This modern plant, devoted to fabricating television, radio, and high fidelity phonograph sets has 415,000 square feet of manufacturing area. Modern production and manufacturing practices are utilized and every television set travels over 5,000 feet of conveyor system. Quality control is stressed continuously throughout each operation. At the conclusion of the tour there will be a demonstration on color television reception.

Material Laboratory of New York Navy Yard, Brooklyn, N. Y. (Thursday afternoon, February 3). This trip will include a visit to the sections devoted to cable, instruments, power, and a-c and d-c short circuit testing. Equipment used for determining the limits of shear, cold bend, dielectric strength, flame resistance, and water tightness of cable will be seen. Test stands and apparatus for life tests of silicone insulated motors, dry rectifiers, carbon brushes, and fuses will be shown. The a-c and d-c testing sections include equipment capable of producing 100,000 amperes, three-phase at 450 volts, as well as the d-c equipment capable of producing 150,000 amperes at 500 volts. (U. S. citizens only.)

Bell Telephone Laboratories, Murray Hill, N. J. (Thursday afternoon, February 3). This laboratory is one of the most modern research facilities in the country. The trip will include an inspection of laboratory areas devoted to metals processing, wood preservation, outside plant, microwave transmission, and acoustic studies. A series of special displays illustrating a number of the newer developments of the Bell Telephone Laboratories which are contributing to better telephone service will also be shown.

THEATER TICKETS

As in the past, tickets to the following shows currently playing in New York will be available to AIEE members during the week of the meeting.

	Evenings		Matinee
	M,T,W,T	F,S	W,S
The Boyfriend	8.00	8.00	5.70
Caine Mutiny Court Martial.. L. Nolan, J. Hodiak, B. Sullivan	5.70	6.60	4.95
Can-Can	8.00	8.00	5.70
Comedy in Music. Victor Borge	5.70	6.85	5.15
Fanny. Ezio Pinza, Walter Slezak	8.00	8.00	5.70
Kismet. Alfred Drake	7.70	7.70	4.95
The Pajama Game. J. Raitt, J. Page, E. Foy, Jr.	8.00	8.00	5.70
The Reclining Figure. Mike Wallace, Martin Gabel	5.70	6.85	4.55
The Solid Gold Cadillac. Loring Smith	5.70	6.85	5.15
The Teahouse of the August Moon. David Wayne, John Forsythe	5.70	7.32	5.13
The Wedding Breakfast. Lee Grant	5.70	6.85	5.15

* All prices shown are brokers' prices.

Checks should be made payable to: "Theater Ticket Committee, AIEE." Requests also should include first and second choice, name and date of show, and should be sent to: Theater Ticket Committee, AIEE, c/o S. Friend, Jr., 75 Buena Vista Drive, Dobbs Ferry, N. Y.

LADIES ENTERTAINMENT

The committee is arranging an attractive program which includes a "Get Acquainted" Tea on Monday afternoon in the Ladies' Headquarters at the Hotel Statler, a dinner and entertainment Tuesday night in the Penn Top, Breakfast at Altman's, Luncheon and Fashion Show in the Jade Room, Waldorf-Astoria on Thursday, tour through the United Nations Building, as well as tours of ships. Coffee will be served each morning from 9:00 to 11:00 a.m. Registration will open in the Georgian Room on

(*Continued on page 74*)

Above is the control room for the cosmotron at Brookhaven National Laboratory, Upton, N. Y. From this room the operators can maintain contact either by public address system or by headphone with colleagues elsewhere in the building, in operating the machine. Through the window can be seen the 2,200-ton magnet, covered by a white plastic "cocoon." On the floor inside this ring-shaped magnet, which has an inside diameter of 65 feet, can be seen a variety of service equipment

Tentative Technical Program

Winter General Meeting, New York, N. Y., January 31-February 4, 1955

Monday, January 31

10:00 a.m. Switchgear

55-213. The Results of Seven Years' Experience with High Capacity Outdoor Oil Breakers. *C. J. Balentine* and *K. G. Darrow*, General Electric Company.

55-216. Dynamics of High Capacity Outdoor Oil Breakers. *Philip Barkan*, General Electric Company.

55-219. Application of Volume Theory of Dielectric Strength to Oil Circuit Breakers. *W. R. Wilson, A. L. Streeter* and *E. J. Tuohy*, General Electric Company.

CP55-220. Capacitance-Switching Facilities at the Switchgear Development Laboratory. *R. L. Williams, L. L. Mankoff* and *H. N. Schneider*, General Electric Company.

10:00 a.m. Transformers

55-43. Evaluation and Application of Silicone-Organic Resin Combinations for Dry-Type Transformer Insulation. *G. F. Simmons* and *A. L. Scheideler*, General Electric Company.

55-44. Functional Temperature Endurance Tests on a Silicone Glass Fiber Insulation System for Dry-Type Transformers. *M. L. Manning*, Pennsylvania Transformer Company.

55-34. Epoxy Resin Casting of Dry-Type Current Transformers. *W. C. Farneth* and *George Gallousis*, Allis-Chalmers Manufacturing Company.

CP.* Functional Life Expectancy Tests for Liquid Filled Distribution Transformers. *A. M. Lackie*, Westinghouse Electric Corporation.

10:00 a.m. Special Communications Applications

55-177. A Tapered Strip Transmission Line for Pulse Transformer Service. *F. G. Primozich*, North American Aviation, Inc., *E. R. Schatz* and *J. B. Woodford*, Carnegie Institute of Technology.

CP55-178. Wartime Telecommunications Experiences. *A. G. Kouts*, Northern Electric Company.

55-179. Economic Design of Saturating Reactor Magnetic Pulsers. *R. A. Mathias* and *E. M. Williams*, Carnegie Institute of Technology.

10:00 a.m. Electrochemical Processes

CP.* Lightning Protection at Chalmette, La., Aluminum Reduction Plant. *G. B. Scheer*, Kaiser Engineers.

CP.* Latest Operating Experience with Mechanical Rectifiers. *A. Hooker*

CP.* Maintenance Practices in Large Converting Substations of Electrochemical Plants. Electrochemical Company.

55-138. Application of Germanium Power Rectifiers. *R. M. Crenshaw*, General Electric Company.

10:00 a.m. Conference on Fields

CP.* Solution of Field Problems with the Aid of Distributed Circuit Parameter Concepts. *S. A. Schelkunoff*, Bell Telephone Laboratories, Inc.

CP.* Effects of Random Variations on the Patterns of Discreet Antennae Arrays. *E. H. Gilbert* and *S. P. Morgan, Jr.*, Bell Telephone Laboratories, Inc.

55-104. An Automatic Field Plotter. *R. Gelfand, B. J. Shinn* and *F. B. Tuteur*, Yale University.

55-105. Improving Field Analogues Through Conformal Mapping. *H. K. Farr* and *W. A. Koen, Jr.*, General Electric Company.

10:00 a.m. Electric Space Heating and Heat Pumps

CP.* A Brief Review of Progress in Heat Pump Development. *E. R. Ambrose*, chairman, Joint AEIC-EEI Heat Pump Committee.

—PAMPHLET reproductions of authors' manuscripts of the numbered papers listed in the program may be obtained from AIEE Order Department, 33 West 39th Street, New York 18, N. Y., as noted in the following paragraphs.

—PRICES of papers, irrespective of length, are 30 cents to members (60 cents to nonmembers) whether ordered by mail or purchased at the meeting. Mail orders are advisable, particularly from out-of-town members, as an adequate supply of each paper at the meeting cannot be assured. Only numbered papers are available in pamphlet form.

—COUPON books in nine-dollar denominations are available for those who may wish this convenient form of remittance.

—THE PAPERS regularly approved by the Technical Program Committee ultimately will be published in the bimonthly publications and Transactions; also, each is scheduled to be published in Electrical Engineering in digest or other form.

CP55-233. A Brief Description of the Design and Operation of Four Heat Pump Installations in the Tennessee Valley. *B. E. Martin*, Tennessee Valley Authority; and *C. L. Carter*, Celanese Corporation.

CP.* Earth Source Heat Pumps Characteristics, Design and Operation. *E. A. Freund* and *G. S. Whitlow*, Union Electric Company of Missouri.

CP.* NEC Provisions for Fixed Electric Space Heating. *John Turnbull*

CP.* Load Characteristics of the Residential Consumer Using Electricity for House Heating. *W. R. Nute*, Tennessee Valley Authority.

55-232. Residential Electric Space Heating in Detroit for 1952–1953 Heating Season. *A. E. Bush* and *R. P. Woodward*, The Detroit Edison Company. Re-presented for discussion.

CP55-237. Alternating-Current Release of Thermal-Electric Devices. *P. L. Betz*, Consolidated Gas, Electric and Power Company of Baltimore.

10:00 a.m. Semi-Conductor Devices

CP.* Switching Transistor Control System for a Magnetic Amplifier. *W. G. Hall* and *R. I. VanNice*, Westinghouse Electric Corporation.

CP.* Silicon Transistor. *A. D. Rittmann*, Philco Corporation.

CP.* Advances in Design and Application of the Double-Base Diode. *J. J. Suran, R. W. Aldrich*, and *I. A. Lesk*, General Electric Company.

CP.* Forming Techniques and Measurements on Gold-Bonded Transistors. *M. W. Aarons, W. E. Bulman* and *E. B. Dale*, Battelle Memorial Institute.

2:30 p.m. General Session

Address: President A. C. Monteith.
Presentation of the Institute paper prizes.
Presentation of the John Scott Medal to Dr. Marvin Camras.
Address: Brig. General David Sarnoff.

Tuesday, February 1

9:30 a.m. Switchgear

55-13. High-Current Testing of Air-Disconnect Switches. *B. F. Gerlin*, Tennessee Valley Authority.

55-9. Results of High-Current Tests on 161-Kv Disconnecting Switches. *A. M. McNerney*, Tennessee Valley Authority.

55-11. Behavior of High-Voltage Busses and Insulators During Short Circuits. *R. M. Milton* and *Fred Chambers*, Tennessee Vally Authority.

55-217. Ribbon Elements for High-Voltage Current Limiting Fuses. *A. H. Powell* and *C. L. Schuck*, General Electric Company.

CP.* Report of International Electrotechnical Commission. *V. L. Cox*, General Electric Company.

9:30 a.m. Section Delegates Conference

9:30 a.m. Electronic Power Converters

55-39. Field Tests on a 100-Megawatt Rectifier Installation. *J. K. Dillard, C. S. Hague*, Westinghouse Electric Corporation; and *John Kiefer*, Reynolds Metals Company.

55-45. Regulation Curves and Transient Currents of Double-Way and Double-Wye Rectifiers. *L. E. Jensen* and *C. E. Rettig*, General Electric Company.

CP.* Safety, Experience and Practice, in the Operation of Mercury Arc Rectifiers in an Aluminum Plant. *R. N. Wagner* and *J. P. Pitman*, Aluminum Company of America.

CP.* Amplistat Regulators for Mercury Arc Rectifiers. *M. M. Morack* and *A. Schmidt, Jr.*, General Electric Company.

9:30 a.m. Transformers

55-31. Recent Contributions to Transformer Audible Noise Control. *W. B. Conover* and *R. J. Ringles*, General Electric Company.

55-26. An Anechoic Chamber for Noise Tests on Large Power Transformers. *A. W. Benoit* (retired); *R. T. Hemmes* and *M. W. Schulz, Jr.*, General Electric Company.

55-12. An Experimental Gas-Insulated 138-Kv Current Transformer. *G. Camilli*, General Electric Company.

9:30 a.m. Antennas and Propagation

CP.* Television Assignment Rules and Policies. *C. B. Plummer*, Federal Communications Commission.

CP.* UHF Wave Propagation. *R. P. Wakeman*, Allen B. DuMont Laboratories.

CP.* Performance of Sectionalized Broadcasting Towers. *C. E. Smith*, Carl E. Smith Consulting Engineers; *D. B. Hutton*, Federal Communications Commission; and *W. G. Hutton*, Goodyear Aircraft Corporation.

55-139. Television Receiver Signal Overload. *C. Marucci*, CBS-Columbia.

9:30 a.m. Thermal Aging of Insulation

55-46. A Method for Evaluation of Thermal Stability of Magnet Wire Enamel. *G. C. Currin* and *J. F. Dexter*, Dow Corning Corporation. Re-presented for discussion.

55-47. Determination of Thermal Life of Enameled Wire by Laboratory Test Methods. *F. A. Sattler*, Westinghouse Electric Corporation. Re-presented for discussion.

CP.* Heat Resistant Magnet Wire. *W. F. Gillian*,

CP* Conference papers will not be printed by the Institute; they may be available, however, at the meeting at the discretion of the author.

E. M. Boldebuck and *J. R. Elliott*, General Electric Research Laboratory.

55-48. Functional Evaluation of Magnet Wire Insulation. *E. L. Brancato* and *R. S. Phillips*, Naval Research Laboratory.

CP.* Thermally Stable Wire Enamel. *F. A. Sattler, J. Swiss* and *C. B. Leape*, Westinghouse Research Laboratories.

CP.* Screening Tests for the Thermal Stability of Magnet Wire. *W. W. Wareham*, General Electric Company.

9:30 a.m. Basic Concepts

CP.* Comments on Definition and Measurement of Physical Quantities with Particular Reference to Rationalized, Nonrationalized, and Gaussian Forms of Maxwells Equations. *S. A. Schelkunoff*, Bell Telephone Laboratories, Inc.

55-49. Recommendations of I.E.C. Technical Committee No. 24 on Electric and Magnetic Magnitudes and Units (E.M.M.U.). *J. J. Smith*, General Electric Company.

CP.* The Definition of Voltage. *W. R. LePage, C. R. Cahn* and *D. W. Spence*, Syracuse University.

CP.* The Definition of Magnetic Vector Potential. *W. R. LePage*, Syracuse University.

9:30 a.m. Insulated Conductors

55-32. Oil Flow and Pressure Calculations for Pipe-Type Cable Systems. AIEE Working Group on Pipe-Type Cable Hydraulics.

55-50. Gas Pressurized, 120 Kv and 161 Kv, Pipe-Type Cables in Ontario. *S. Kozak*, Canada Wire and Cable Company, Ltd.; and *C. Prescott*, Hydro-Electric Power Commission of Ontario.

CP55-40. Freezing Pipe Type Cable. *E. J. Merrell*, Phelps Dodge Copper Products Corporation.

CP.* Charging Current Limitations on Power Output of High Voltage Cable Lines. *C. S. Schifreen* and *W. C. Marble*, Philadelphia Electric Company.

55-51. An Improved Approximate Technique for Calculating Cable Temperature Transients. *F. C. Van Wormer*, General Electric Company.

9:30 a.m. Land Transportation

55-202A. Ignitron Multiple-Unit Cars for the New Haven Railroad. *E. W. Ames*, Westinghouse Electric Corporation; and *V. F. Dowden*, New York, New Haven and Hartford Railroad Company.

55-203. Considerations in Applying D-C Traction Motors on Rectified Single-Phase Power. *M. Simon*, General Electric Company.

55-204. Thermal Stability of a New Insulating Material Used in Traction Motors. *R. W. Finholt*, General Electric Company.

55-205. A New Power Supply for Railway Cars. *E. F. Bradenberg*, General Electric Company.

9:30 a.m. Direct Current Machines

55-106. Correlation of Temperature Measurements on D-C Armatures. *D. D. Gerbets* and *J. W. Ewing*, Reliance Electric and Engineering Company.

55-107. A Circuit Approach to the Analysis of a Two Stage Dynamo-Electric Amplifier. *R. W. Burtness*, La Grange Park, Ill.

CP55-108. Metadyne Transients. *K. A. Fegley*, University of Pennsylvania.

55-109. D-C Machines: Response to Impact Excitation. *J. J. Brockman* and *C. E. Linkous*, General Electric Company.

9:30 a.m. Transistor Reliability—I-Devices

CP.* A Survey of the Scientific Aspects of Transistor Reliability. Part A: *G. W. Pratt*, Massachusetts Institute of Technology. Part B: *J. E. Thomas*, Massachusetts Institute of Technology.

CP.* A Reliable Point Contact Transistor for Military Operations. *N. J. Herbert*, Bell Telephone Laboratories, Inc.

CP.* Reliability of Hermetically Sealed Junction Transistors. *C. H. Zierdt*, General Electric Company.

9:30 a.m. Safety

S-69. Bibliography on Electrical Safety—1930–1953. *J. A. Gienger*, Eastman Kodak Company; and *R. L. Lloyd* National Bureau of Standards. Re-presented for discussion.

CP55-239. Practical Effects of Electricity on the Heart. *S. A. Talbot*, The Johns Hopkins Hospital.

55-95. Electric Defibrillation. *W. B. Kouwenhoven* and *W. R. Milnor*, The Johns Hopkins University.

55-87. Field Current Sources for Electric Defibrillation. *P. L. Betz*, Consolidated Gas Electric Light and Power Company of Baltimore.

1:45 p.m. Presentation of the John Fritz Medal to Harry A. Winne

2:30 p.m. Switchgear

55-218. A 69 Kv Compressed Air Circuit Breaker for 5,000,000 Kva. *R. E. Kane* and *J. K. Walker*, Westinghouse Electric Corporation.

55-215. High Current Arc Erosion of Electric Contact Materials. *W. R. Wilson*, General Electric Company.

55-221. Short-Circuit Currents and Circuit Breaker Recovery Voltages Associated with Two Phase-to-Ground Short-Circuits. *W. F. Skeats*, General Electric Company.

55-222. Field Tests on a 138 Kv High Speed Oil Circuit Breaker at Philip Sporn Power Plant. *O. Nasf*, American Gas and Electric Company; and *R. D. Hambrick*, Federal Pacific Electric Manufacturing Company.

2:30 p.m. Section Delegates Conference

2:30 p.m. Transformers

55-30. Magnetization of Transformer Cores During Impulse Testing. *M. F. Beavers, J. E. Holcomb* and *L. C. Looni*, General Electric Company.

55-29. Oscillations of Coupled Windings. *P. A. Abetti, G. E. Adams* and *F. J. Maginniss*, General Electric Company.

55-52. Thyrite Protection for Series Windings of Autotransformers. *J. W. Albright*, General Electric Company.

CP55-27. Impulse Tests on the Low-Voltage Windings of Distribution Transformers. *J. E. Holcomb*, General Electric Company.

2:30 p.m. Color Television

CP.* Design for Production of Color Television Receivers. *J. P. Vandure*, Westinghouse Electric Corporation.

CP.* Chromacoder. *P. C. Goldmark* and *J. F. Bambara*, Columbia Broadcasting System.

CP.* Development of the RCA 21-Inch Metal Envelope Color Kinescope. *H. R. Seelen, H. C. Moodey, D. D. Van Ormer* and *A. M. Morrell*, Radio Corporation of America.

CP.* Deflection and Convergence of the RCA 21-Inch Color Kinescope. *M. J. Obert*, Radio Corporation of America.

2:30 p.m. Cathodic Protection

55-111. Electrical Grounding Systems and Corrosion. *L. P. Schaefer*, The Hinchman Corporation.

55-113. Underground Corrosion on Rural Electric Distribution Lines. *O. W. Zastrow*, Rural Electrification Administration.

CP.* Panel Discussion on Electrical Grounding in Cathodically Protected Systems.

55-110. Electrical Grounding and Cathodic Protection at the Fairless Works. *W. E. Coleman* and *H. G. Frostick*, U. S. Steel Corporation. Re-presented for discussion.

2:30 p.m. Thermal Aging of Insulation

CP.* Magnetic and Electrical Properties of Polymers Subjected to Thermal Aging. *F. H. Winslow, W. O. Baker*, and *W. A. Yager*, Bell Telephone Laboratories, Inc.

CP55-234. Appraisal of High Temperature Behavior Laminates with Time. *G. E. Power*, Formica Company.

CP.* Heat Aging of Teflon Tetrafluoroethylene. *G. McMahon* and *B. E. Ely*, E. I. duPont de Nemours and Company, Inc.

55-35. Insulation Aging Characteristics as Measured by Shearing Modulus. *L. C. Whitman* and *A. L. Scheidler*, General Electric Company.

CP.* Heat Resistant Insulation for Motors. *J. H. Clawson, C. J. Herman* and *K. N. Mathes*, General Electric Company.

CP.* Measurement of Thermal Aging of Insulation Over Varying Temperature Cycles. *H. M. Philofsky, F. A. Sattler* and *T. W. Dakin*, Westinghouse Research Laboratories.

2:30 p.m. Insulated Conductors

55-53. Aluminum Sheathed Power Cable. *W. A. Del Mar* and *E. J. Merrell*, Phelps Dodge Copper Products Corporation.

55-54. Mineral-Insulated Metallic-Sheathed Cables. *C. A. Jordan* and *G. S. Eager, Jr.*, General Cable Corporation.

55-55. An Analogue Solution of Cable Heat Flow Problems. *E. deHaas, P. J. Sandiford* and *A. W. W. Cameron*, Hydro-Electric Power Commission of Ontario.

55-56. The Co-ordination of Power and Communication Cable Characteristics. *H. D. Short*, Canada Wire and Cable Company.

2:30 p.m. Land Transportation

55-206. Rectifier Locomotives for the New York New Haven and Hartford Railroad. *F. D. Gowans* General Electric Company.

CP55-207. Multiple Unit Rectifier Motive Power Inductive Coordination Considerations on the New York, New Haven and Hartford Railroad. *L. J. Hibbard*, Westinghouse Electric Corporation; *F. T. Garry*, Southern New England Telephone Company; and *G. N. Loomis*, New York, New Haven and Hartford Railroad.

55-208. Considerations in the Development of a High-Power Rectifier Locomotive. *H. S. Ogden*, General Electric Company.

55-209. Graphic Aids for Calculating Rectifier Locomotive Performance. *R. D. Charlton*, General Electric Company.

55-210. An Electric Drive for Rotary Snow Plows. *A. H. Hoffer* and *R. E. Willhite*, General Electric Company.

2:30 p.m. Direct Current Machines

55-112. D-C Machines—A Method for Short-Circuit Calculation. *John Cybulski* and *J. P. O'Connor*, Naval Research Laboratory.

55-114. D-C Machines—Short Circuit Calculation and Test Results. *J. P. O'Connor* and *John Cybulski*, Naval Research Laboratory.

CP55-228. D-C Power Systems—Short Circuit Calculations and Test Results. *John Cybulski* and *J. P. O'Connor*, Naval Research Laboratory.

55-115. The Induction Machines with Solid Iron Rotor. *H. M. McConnell* and *E. F. Swerdrup*, Carnegie Institute of Technology.

2:30 p.m. Transistor Reliability—II-Circuits

CP.* Small Signal Low Frequency Transistor Amplifier. *F. M. Dukat*, Raytheon Manufacturing Company.

CP.* Transistor Radio Circuits. *N. B. Saunders*, Consulting Engineer.

CP.* Junction Transistor Switching Circuits. *R. H. Baker*, Massachusetts Institute of Technology.

CP.* Point Contact Transistor Switching Circuits. *J. A. DiGiorgio* and *A. W. Carlson*, Air Force Cambridge Research Center.

2:30 p.m. Preventing Fires from Electrical Causes

CP.* Electrical Fire Loss Statistics. *C. L. Smith*, National Fire Protection Association.

CP.* Prevention of Fires from Electrical Causes in Plant and Building Wiring. *W. H. Biester, Jr.*, Electro Construction Company.

CP.* Reduction of Fire Hazard in the Design and Application of Electric Motors. *Sol London*, General Electric Company.

CP.* Preventing Fires from Electrical Causes in the Design and Manufacture of Appliances. *H. A. Strickland, Jr.*, and *R. A. Ackerman*, Hotpoint Company.

CP.* Preventing Fires from Electrical Causes in the Design and Manufacture of Radio and Television Receivers. *H. T. Heaton*, General Electric Company.

2:30 p.m. Magnetic Amplifiers

55-57. A Fast Response Magnetic Servo Amplifier. *J. W. Kallander*, Naval Research Laboratory.

55-58. A New Full-Wave Magnetic Amplifier Output Stage. *P. W. Barnhart*, Feedback Controls, Inc.

55-59. Elimination of Asymmetry Zero-Drift Errors in Magnetic Servo Amplifiers. *W. A. Geyger*, U. S. Naval Ordnance Laboratory.

55-60. Magnetic-Amplifier Control of D-C Motors. *A. Kusko*, Massachusetts Institute of Technology and *J. G. Nelson*, Minneapolis-Honeywell Regulator Company.

55-61. 160,000 Ampere, High Speed Magnetic Amplifier Design. *A. B. Rosenstein*, University of California.

Wednesday, February 2

9:30 a.m. Switchgear

55-102. Analysis of Fault Currents for High Voltage Circuit Breaker Interruption. *M. J. Lantz*, Bonneville Power Administration.

55-223. Design Problems and Field Tests Concerning Circuit Breakers for Switching Long 230 Kv Lines. *E. M. Umphrey* and *D. J. Marsden*, Federal Pacific Electric Company.

55-212. Test Circuits for Capacitance Switching Devices. *K. G. Darrow, V. E. Phillips, A. J. Schultz* and *R. B. Shores*, General Electric Company.

55-224. Some Fundamentals on Capacitance Switching. *I. B. Johnson, A. J. Schultz, N. R. Schultz* and *R. B. Shores*, General Electric Company.

9:30 a.m. Wire Communications

55-229 Telephone Lines for Rural Subscriber Service. *L. Hackgraf* and *R. G. Watling*, Bell Telephone Laboratories, Inc.

CP.* A Subscriber Carrier Telephone System, Description, Equipment and Utilization. *James MacDonnell*, North Electric Manufacturing Company.

CP.* Recent Developments in Subscriber Carrier Equipment. *W. Fingerle*, Budelman Radio Corporation.

CP.* Type S (FM) Subscriber Carrier Equipment. *Clem Boucher* and *Wendell Boucher*, McElroy Manufacturing Corporation.

CP.* Use of Subscriber Line Carrier Equipment in the Design of Rural Telephone Systems. *W. T. Smith* and *J. M. Flanigan*, Rural Electrification Administration.

CP.* Problems and Promises of Rural Carrier. *H. R. Huntley*, American Telephone and Telegraph Company, and *J. W. Emling*, Bell Telephone Laboratories.

9:30 a.m. Petroleum Industry

CP55-62. Modernization of the Electrical Distribution System: Tide Water Associated Oil Company—Avon Refinery. *W. H. East*, Tide Water Associated Oil Company; and *G. R. Dunbar*, Westinghouse Electric Corporation.

CP55-20. Lighting a Modern Refinery Process Unit. *E. A. Clarke*, Humble Oil and Refining Company.

55-63. Basic Circuitry for Electrically Powered Pipeline Pump Stations Under Automatic or Remote Control. *M. A. Hyde* and *W. A. Derr*, Westinghouse Electric Corporation. Re-presented for discussion.

CP.* Operating Experience with Electrical Transducers for Pipe Line Pressure and Flow Measurements and Controls. *R. S. Cannon* and *W. W. Holt*, Plantation Pipe Line Company.

9:30 a.m. Electronic Aids to Navigation

CP.* Long-Distance Navigation—Past, Present and Future. *J. A. Pierce*, Harvard University.

CP.* Electronic Navigation Over Land Areas. *Vernon Weihe*, Air Transport Association of America (and) Melpar, Inc.

CP.* Electronic Guidance of Aircraft in the Vicinity of Airports. *Peter Sandretto*, Federal Telecommunications Laboratories.

9:30 a.m. Symposium on Liquid Dielectrics

CP55-54. Properties of Oil Affecting Its Use in Apparatus. *F. J. Vogel*, Allis-Chalmers Manufacturing Company.

55-65. Empirical Formulas for the 60-Cycle Spark-over Gradients in Commercial Oil. *W. F. Gauster*, North Carolina State College.

55-66. Gas and Moisture Equilibria in Transformer Oil. *R. B. Kaufman, E. J. Shimanski* and *K. W. MacFadyen*, General Electric Company.

CP.* Some Factors Influencing Electric Breakdown in Liquids. *A. H. Sharbaugh*, General Electric Company.

CP55-103. The Effect of Gamma Radiation on Liquid Dielectrics. *T. D. Callinan*, U. S. Naval Research Laboratory.

CP.* Characteristics of Corona Discharges in Liquid Dielectrics. *T. W. Dakin, D. Berg*, Westinghouse Electric Corporation.

9:30 a.m. Circuit Theory

55-140. A Supplement to the Brune Synthesis. *F. M. Reza*, Massachusetts Institute of Technology. Re-presented for discussion.

CP.* Mathematical Properties of Root Loci for Control-System Design. *F. Reza*, Massachusetts Institute of Technology.

CP.* A Note on Network Approximation Functions. *N. Balabanian*, Syracuse University.

CP.* Is the Impulse Function Necessary or Desirable in Network Theory? *M. B. Reed* and *C. L. Coates*, University of Illinois.

CP.* Response of Certain Basic Circuits to a Sine-Squared-Loop Voltage Pulse. *T. J. Higgins*, University of Wisconsin; and *O. H. Bieck*, Allen-Bradley Corporation.

9:30 a.m. Feedback Control Systems

55-185. Further Effects of the Pole and Zero Locations on the Step Response of Fixed, Linear Systems. *A. H. Zemanian*, New York University.

55-186. The Effect of Pole and Zero Locations on the Transient Response of Sampled-Data Systems. *E. I. Jury*, University of California.

55-187. An Analytical Method for the Design of Relay Servomechanisms. *J. E. Hart*, Naval Research Laboratory.

55-188. A Method for Evaluating Nonlinear Servomechanisms. *M. V. Mathews*, Massachusetts Institute of Technology.

55-202. Conditional Feedback Systems—A New Approach to Feedback Control. *G. Lang*, Ferranti Electric, Ltd.; and *J. M. Ham*, University of Toronto.

55-189. Analysis of Errors in Sampled-Data Feedback Systems. *J. Sklansky* and *J. R. Ragazzini*, Columbia University. Re-presented for discussion.

55-190. Transient Analysis of A-C Servomechanisms. *S. S. L. Chang*, New York University. Re-presented for discussion.

55-15. Analysis of Backlash in Feedback Control Systems with One Degree of Freedom. *L. M. Vallese*, Polytechnic Institute of Brooklyn. Re-presented for discussion.

9:30 a.m. Synchronous Machines

55-116. Operation of Hydrogen Cooled Turbine Generators. *C. C. Sterrett* and *R. A. Towne*, Westinghouse Electric Corporation.

55-117. Turbine Generator, Operation and Maintenance Practice of Philadelphia Electric Company. *E. I. Gallagher*, Philadelphia Electric Company.

55-118. Turbine Generator Stator Winding Temperatures at Various Hydrogen Pressures. *J. R. M. Alger, C. E. Kilbourne, D. S. Snell*, General Electric Company.

55-119. Steam Turbine-Generator Operating and Maintenance Methods of the Southern California Edison Company. *C. L. Sidway* and *C. M. Clevenger*, Southern California Edison Company.

CP.* Operation and Maintenance of Hydrogen Systems for Turbine Generators. *S. C. Barton* and *W. H. M. Olson*, General Electric Company.

9:30 a.m. Magnetic Amplifiers

55-68. An Analysis of Optimum Core Configuration for Magnetic Amplifiers Introducing a Simplified Method. *B. D. Bedford, G. C. Dodson*, General Electric Company and *C. H. Willis*, Princeton University.

55-21. Inductive Load Instability in Magnetic Amplifiers. *H. I. Lam* and *A. B. Rosenstein*, University of California.

55-69. Analysis and Design of a Magnetic Frequency Multiplier. *O. J. M. Smith* and *J. T. Salihi*, University of California.

55-70. An All-Magnetic Audio Amplifier System. *J. J. Suozzi* and *E. T. Hooper*, U. S. Naval Ordnance Laboratory.

CP55-71. Voltage Gain of a Resonant Dielectric Amplifier. *E. A. Sack*, Westinghouse Electric Corporation; and *G. W. Penney*, Carnegie Institute of Technology.

9:30 a.m. Computing Devices

CP.* Transfer Function Synthesis with Computer Amplifiers and Passive Networks. *M. V. Mathews* and *W. W. Seifert*, Massachusetts Institute of Technology.

CP.* Simulation by Modelling Techniques. *Norman Irvine*, Aerojet Corporation.

CP.* The Evolution of the Electric Analogue Computer. *G. D. McCann*, California Institute of Technology.

55-5. Computer for Automatizing Network-Analyser Operation. *A. Kusko*, Massachusetts Institute of Technology and *P. N. Heller*, Raytheon Manufacturing Company.

9:30 a.m. System Engineering

55-25. The Determination of Incremental and Total Loss Formulas from Functions of Voltage Phase Angles. *C. R. Cahn*, Syracuse University.

55-90. A General Transmission Loss Equation. *E. D. Early, G. L. Smith*, Southern Services, Inc.; and *R. E. Watson*, Leeds and Northrup Company.

55-141. An Incremental Cost of Power Delivered Computer. *E. D. Early*, Southern Services, Inc., *W. E. Phillips* and *W. T. Shreve*, Leeds and Northrup Company.

55-24. Load-Phase-Tie Line Energy Control of Interconnected Power Systems. *F. Cahen*, Electricite de France.

9:30 a.m. Engineering Code of Ethics

CP.* Ethics for the Engineering Profession. *T. M. Linville*, General Electric Company.

CP.* Canons of Ethics for Engineers—Their History and Future Importance. *R. E. Argersinger*, Stone and Webster Engineering Corporation.

1:45 p.m. Presentation of the Edison Medal to Oliver E. Buckley

2:30 p.m. Switchgear and Substations

55-225. Pittsburgh Downtown 69 Kv Power Supply—Part I—Planning. *V. E. Hill*, Duquesne Light Company.

55-226. Pittsburgh Downtown 69 Kv Power Supply—Part II—Substation. *E. M. Gus*, Duquesne Light Company.

55-214. Pittsburgh Downtown 69 Kv Power Supply—Part III—Switchgear. *P. R. Pierson*, Westinghouse Electric Corporation.

CP55-227. An Air Supply System for Compressed Air Circuit Breakers. *J. E. Schramack*, Westinghouse Electric Corporation.

2:30 p.m. Wire Communications

55-230. A Transatlantic Telephone Cable. *M. J. Kelly, G. W. Gilman*, Bell Telephone Laboratories, Inc.; *Sir W. Gordon Radley* and *R. J. Halsey*, Post Office of the United Kingdom.

55-231. Open-Wire Carrier Systems in South Africa. *G. F. Boyes*, Government Post Office, Pretoria, South Africa.

CP.* Frequency Shift Signaling Circuit for 45 Type Carrier Systems. *R. S. Caruthers* and *K. E. Appert*, Lenkurt Electric Company.

CP.* Cable Dancing. *N. Aamodt*, Bell Telephone Laboratories.

CP.* Experiences with "B" Rural Distribution Wire. *J. C. Lafel*, Michigan Bell Telephone Company.

2:30 p.m. Industrial Power Systems

55-142. Time Variation of Industrial System Short-Circuit Currents and Induction Motor Contributions. *W. C. Huening, Jr.*, General Electric Company.

CP55-244. Surge Protection on Industrial Systems. *C. L. Wagner*, Westinghouse Electric Corporation.

CP55-145. Directional Relays Provide Differential Type Protection on Large Industrial Plant Power System. *M. M. Gilbert* and *R. N. Bull*, E. I. Du Pont de Nemours and Company.

2:30 p.m. How Can the Utilities Best Make Use of Modern Science?

55-144. Implementation of a Research Program for the Electric Utility Industry. *J. E. Hobson, M. S. Oldacre*, Stanford Research Institute; and *W. A. Lewis*, Illinois Institute of Technology.

55-145. Research in the Electric Power Industry. *L. R. Gaty*, Philadelphia Electric Company.

CP55-245. The Role of the Manufacturer in Utility Research. *E. E. Parker* and *J. Baird*, General Electric Company.

CP55-40.* Educating Electrical Engineers to Exploit Science. *G. S. Brown, Alexander Kusko* and *D. C. White*, Massachusetts Institute of Technology.

2:30 p.m. Liquid and Gaseous Dielectrics

55-72. Phenomena Accompanying Transient Low-Voltage Discharges in Liquid Dielectrics-I. Anode Phenomena at Low Currents. *E. M. Williams* and *R. E. Smith*, Carnegie Institute of Technology.

55-36. The Propagation Mechanism of Impulse Creepage Discharges over Oil-Immersed Surfaces. *J. G. Andersen* and *T. W. Liao*, General Electric Company.

CP55-24. The Dielectric Behavior of Some Fluorogases and Their Mixtures with Nitrogen. *G. Camilli, T. W. Liao*, and *R. E. Plump*, General Electric Company.

CP.* Dielectric Breakdown of Perfluorocarbon Vapors and Gases and their Mixtures with Nitrogen. *L. J. Berberich, C. N. Works* and *E. W. Lindsey*, Westinghouse Electric Corporation.

55-10. Some Electrical and Thermal Characteristics of Helium and Sulfur-Hexafluoride Mixtures. *J. D. Cobine*, General Electric Research Laboratory.

55-37. Significant Factors in Thermal Aging Tests on Flexible Sheet Insulation. *T. W. Dakin, H. M. Philofsky* and *W. G. Dixon*, Westinghouse Electric Corporation. Re-presented for discussion.

2:30 p.m. Chemical Industry

CP55-238. Emergency Power Supply in Chemical Manufacturing Operations. *R. F. Shuman*, Dow Chemical Company.

CP.* Modern Trends in Design of Electrical Distribution Systems in Chemical Plants. *G. B. Jamison*, Crouse-Hinds Company.

CP.* Training Program to Qualify Plant Electricians as Satisfactory High Voltage Cable Splicers. *T. O. Wood*, Dow Chemical Company.

CP.* Lightning Protection of Chemical Plant Structures. *A. M. Opstahl*, Westinghouse Electric Corporation.

2:30 p.m. Transmission and Distribution

55-91. Automatically Switched Capacitors in Steps on a Single Distribution Feeder. *W. C. Fowler*, Sangamo Electric Company; and *C. W. Thomas*, Public Service Company of Oklahoma.

55-146. Balancing Double-Wye High Voltage Capacitor Banks. *O. R. Compton*, Virgina Electric and Power Company.

55-41. Fundamental Relations of System Voltage Drop and System Loads. *G. M. Miller* and *L. W. Robbins*, General Electric Company.

55-89. A Simplified Method of Calculating Voltage Regulation Using Unit Impedance Power-Reactive Diagrams. *R. M. Butler*, General Electric Company.

2:30 p.m. Feedback Control Systems

55-191. Frequency Response from Experimental Nonoscillatory Transient-Response Data. *H. Thal-Larsen*, University of California.

55-192. A Series Method of Calculating Servomechanism Transient Response from the Frequency Response. *D. V. Stallard*, Massachusetts Institute of Technology.

55-193. A Method for the Preliminary Synthesis of a Complex Multi-Loop Control System. *D. J. Powejril* and *A. M. Fuchs*, Westinghouse Electric Corporation.

55-194. Design of Control Systems for Minimum Bandwidth. *G. C. Newton*, Massachusetts Institute of Technology.

CP.* The Use of Short-Time Memory Units in Feedback Control Systems. *T. W. Sze* and *J. F. Calvert*, Northwestern University.

55-195. A General Theory for Determination of the Stability of Linear Lumped-Parameter Multiple-Loop Servomechanisms (and other Feedback Systems). *T. S. Amlie*, U.S. Naval Ordnance Test Station; and *T. J. Higgins*, University of Wisconsin. Re-presented for discussion.

55-196. Design and Application of a Peak Voltage Detector to Industrial Control Systems. *L. W. Allen*, International Business Machines Corporation. Re-presented for discussion.

2:30 p.m. Synchronous Machines

55-120. Operation of Turbine-Generators During Off-Peak High Power-Factor Periods—Practices of One Utility in a Metropolitan Area. *W. J. Roberts* and *R. L. Webb*, Consolidated Edison Company of New York, Inc.

CP.* Operation of Turbine Generators. *J. H. Carter* and *R. E. Gorman*, General Electric Company.

55-121. Eccentricity, Vibration and Shaft Currents in Turbine Generators. *L. T. Rosenberg*, Allis-Chalmers Manufacturing Company.

CP55-122. Proposed Guide for Maintenance of Turbine-Generators. *J. W. Jones*, Philadelphia Electric Company.

55-123. Test Report on a Fully Supercharged Generator. *S. Beckwith, B. M. Koetting, L. T. Rosenberg* and *G. W. Staats*, Allis-Chalmers Manufacturing Company.

2:30 p.m. Magnetic Amplifiers

55-67. Transistor Demodulator for High-Performance Magnetic Amplifiers in A-C Servo Applications. *R. O. Decker* Westinghouse Electric Corporation.

55-73. A Switching Transistor D-C to A-C Converter Having an Output Frequency Proportional to the D-C Input Voltage. *G. H. Royer*, Westinghouse Electric Corporation.

55-74. A High-Accuracy Static Time Delay Device Utilizing Transistors. *G. F. Pittman, Jr.*, Westinghouse Electric Corporation.

55-75. A Variable Frequency Magnetic-Coupled Multivibrator. *R. L. Van Allen*, Naval Research Laboratory.

CP55-76. The Level Comparator. *H. Estrada, Jr.*, and *J. P. Ward*, Westinghouse Electric Corporation.

2:30 p.m. Computers and Special Instrumentation

55-180. Electronic Computer for Color Printing. *H. E. Rose*, Radio Corporation of America.

CP.* The Thermal Printer. *Herman Epstein*, Burroughs Corporation.

CP55-181. Raydist Systems for Radiolocation and Tracking. *J. M. Benson* and *J. E. Swafford*, Hastings Instrument Company.

CP55-182. An Azimuth and Elevation Photorecording Theodolite. *S. W. Silverman*, Boeing Airplane Company.

2:30 p.m. Management

CP.* An Engineering Society's Responsibilities in the Management Field. *L. E. Neuman*, General Electric Company.

CP.* Economic Counsel and Modern Management. *J. R. Haas*, Lionel D. Edie and Company.

Thursday, February 3

9:30 a.m. Carrier Current

55-77. A Method of Measurement of Carrier Characteristics on Power Cables. *B. J. Sparlin* and *J. D. Moynihan*, Westinghouse Electric Corporation

55-78. Design of the Adjustable Lin-O-Phase Filter. *Reuben Lee*, Westinghouse Electric Corporation.

55-79. An Investigation of the Capture Effect in a Narrow Band Frequency Modulated System. *C. D. Hodges*, Westinghouse Electric Corporation.

55-42. Recommendations for Improving Reliability of Standby Engine Generators for Microwave Communications Systems. *N. B. Tharp*, Westinghouse Electric Corporation

9:30 a.m. Communication Switching Systems

CP.* Little Audrey—A Voice Controlled Logic Machine. *G. R. Frost*, Bell Telephone Laboratories, Inc.

CP.* The Outguesser and Other Semi-intelligent Machines. *D. W. Hagelbarger*, Bell Telephone Laboratories, Inc.

CP.* A Demonstration of Common Control Telephone Switching Principles. *V. F. Blefary*, Bell Telephone Laboratories, Inc.

9:30 a.m. Industrial Control

CP.* Utilizing the Magnetic Amplifier for Processing Line Loop Control. *K. S. Yamamoto*, Clark Controller Company.

CP.* Computer Analysis of Industry Control Regulating Systems. *W. W. Bolander* and *J. T. Bradford*, General Electric Company.

55-80. Eddy Current Press Drives. *F. L. Hopf* and *T. R. LaValley*, Dynamatic Corporation.

CP.* Automatic Positioning of a Rotary Turret Punch Press. *D. B. Schneider*, General Electric Company.

9:30 a.m. Solid Dielectrics and Miscellaneous

55-81. Surface and Volume Dielectric Losses. *J. J. Chapman, L. F. Blickley* and *E. A. Szymkowiak*, The Johns Hopkins University.

55-82. Dielectric Failure of Volume and Surface Types. *J. J. Chapman, L. J. Frisco* and *J. S Smith*, The Johns Hopkins University.

CP.* The Underwater Spark: A Photographic Light Source of High Brilliance. *H. C. Early* and *E. A. Martin*, University of Michigan.

CP.* Velocities of Magnetically Driven Arcs in Air and Helium up to 30 Atmospheres. *R. C. Walker* and *H. C. Early*, University of Michigan.

55-83. A Continuous Flow Moisture Detector. *M. F. Beavers, E. J. Shimanski* and *E. F. Timpano*, General Electric Company.

9:30 a.m. Recent Developments in Semiconductors

CP.* Thermoelectric Properties of Semiconductors. *T. H. Geballe*, Bell Telephone Laboratories, Inc.

CP.* Carrier Extraction in Germanium. *Ralph Bray*, Purdue University.

CP.* Cyclotron and Other Resonance Effects in Silicon and Germanium. *J. H. Zeiger*, Massachusetts Institute of Technology.

CP.* Organic Semiconductors. *George Goldsmith*, Purdue University.

9:30 a.m. Computing Devices

CP.* A Self-Checking Card-to-Magnetic-Tape Converter. *E. I. Blumenthal*, Remington Rand Inc.

CP55-243. A New Magnetic Memory Device for Business Machines. *S. J. Begun*, Clevite-Brush Development Company.

55-147. An Electronic System for Processing Air Traffic Control Information. *R. M. Kalb*, Engineering Research Associates.

55-148. Data Transfer and Display Equipment for a Proposed System of Air Traffic Control. *G. E. Fenimore*, Civil Aeronautics Administration.

9:30 a.m. Transmission and Distribution

55-22. Voltage Gradients on High Voltage Transmission Lines. *G. E. Adams*, General Electric Company.

55-98. Measurement of Resistance and Reactance of Expanded ACSR. *J. Tompkins, B. L. Jones* and *P. D. Tuttle*, Aluminum Company of America.

54-501. Practical Application of Sag and Tension Calculations to Transmission Line Design. *J. Lummis* and *H. D. Fischer, Jr.*, Southern California Edison Company.

55-149. Investigation of European Practices in Power Line Design. *Eduard Fritz*, Day and Zimmermann, Inc.

9:30 a.m. Relay Committee and Synchronous Machinery

CP.* The Physical Effect of Thermal Cycling on Insulation for Long Stator Coils in Turbine Generators. *J. S. Johnson*, Westinghouse Electric Corporation.

CP.* Experience in DC Testing of AC Generator Insulation. *A. Pleteník*, General Electric Company.

55-3. Effect of Synchronous-Machines Transient Rotor Saliency on Changes in Terminal Voltage. *C. Concordia*, General Electric Company.

55-124. A Transductor Type Field Ripple Detector for Synchronous Generators. *H. M. McConnell*, Carnegie Institute of Technology.

55-125. Detection of Grounds in Generator Field Windings. *J. E. Barkle, C. C. Sterrett*, and *L. L. Fountain*, Westinghouse Electric Corporation.

9:30 a.m. Instruments

55-2. An Airborne Temperature Indicator. *W. R. Clark, W. G. Amey* and *G. C. Morgner*, Leeds and Northrup Company.

55-155. An Elliptical Polarization Synthesizer. *G. H. Friedman*, Franklin Institute Laboratories. Re-presented for discussion

55-14. The Ring Modulator as a Polarized Rectifier. *A. J. Hermont*, Shell Development Company.

55-1. A Novel Circuit for Electronic Power-Factor Meters and Wattmeters and a Novel Division Device. *M. Abdel-Halim Ahmed*, Cairo University.

9:30 a.m. Education

Panel Discussion: The American Society of Engineering Education Report on Evaluation of Engineering Education—Its Relationship to Electrical Engineering

1. **The Background of the Report and Its Conclusions.** *L. E. Grinter*, University of Florida.

2. **Implications for Electrical Engineering Curricula.** *J. F. Calvert*, University of Pittsburgh.

3. **Implications for Industry.** *G. E. Moore*, Westinghouse Electric Corporation.

4. **Implications for the Professional Engineer.** *R. G. Warner*, United Illuminating Company.

9:30 a.m. Substations

55-127. Control Circuitry for Remotely Operated Electric Utility Substations. *W. A. Derr* and *W. L. Matz*, Westinghouse Electric Corporation.

55-128. Supervisory Control and Associated Telemetering Equipment. Working Group of the Automatic and Supervisory Control Subcommittee.

CP55-17. Automatic Switching of Substation Static Capacitor Banks by a Current Biased Induction Disc Type Voltage Relay. *W. C. Ostem* and *J. J. McCullough*, Southern California Edison Company.

CP 55-169. Methods of By-Passing Distribution Substation Equipment. *J. A. Smith* and *D. J. Hubert*, General Electric Company.

9:30 a.m. Electron Equipment Reliability—I

55-151. Science, Statistics and Reliability Engineering. *J. C. Bear*, Aeronautical Radio, Inc.

CP.* Integrating Statistical and Probability Methods to Engineering Design. *E. B. Ferrell*, Bell Telephone Laboratories, Inc.

CP.* The Application of Statistical Techniques to Electron Tubes for Use in a 4000-Mile Transmission System. *W. VanHaste* and *B. J. Kinzburg*, Bell Telephone Laboratories, Inc.

2:00 p.m. Radio Communications

CP55-199. FDM Subcarrier. *A. R. Vallarino* and *C. Grunwald*. Federal Telecommunication Laboratories.

55-200. Coaxial Cavity Filters for Multiplexing of 900-Megacycle Radio Relay Systems. *M. H. Kehby*, Lenkurt Electric Company.

55-201. A Communications System for the New York State Thruway. *D. S. DeWire*, New York Telephone Company; and *H. A. Evans*, New York State Thruway Authority.

CP.* Very High Frequency Radio Link from Puerto Rico to the Virgin Islands. *R. McSweeny*, Mackay Radio and Telegraph Company.

2:00 p.m. Industrial Control

55-84. An Eddy Current Braking Crane-Hoist Controller with Variable Brake Excitation. *H. J. Raithhun*, The Electric Controller and Manufacturing Company.

55-85. Transient Analysis of a DC Electromagnet with Cut-Out Switch. *T. H. Lee*, General Electric Company.

CP.* Safety in Industrial Controls. *T. C. Beeman* and *R. J. Kantner*, Clark Controller Company.

55-86. An Adjustable Speed Power Selsyn System. *S. Y. Merritt*, Aluminum Company of America.

2:00 p.m. Computing Devices

CP.* Cyclic Decimal Codes for Analogue to Digital Converters. *J. A. O'Brien*, Radio Corporation of America.

CP.* Special Purpose Magnetic Core Circuits. *R. D. Rodis*, Raytheon Manufacturing Company.

CP.* Magnetic Elements in Arithmetic and Control Circuits. *I. L. Auerbach* and *S. B. Disson*, Burroughs Corporation

CP.* Junction Transistor Flip-Flop Design Methods for Computer Applications. *T. P. Bothwell*, Radio Corporation of America.

2:00 p.m. Transmission and Distribution

CP.* 115 Kv Transmission Conductor Bundling—Pennsylvania Electric Company, *P. L. Lumnitzer*, Pennsylvania Electric Company.

CP55-153. Joint Testing for High Voltage Transmission Lines. *A. S. Runciman*, The Shawinigan Water and Power Company.

CP.* Field Treatment of Existing Poles. *L. E. Lockwood* and *J. C. Bice*, Commonwealth Edison Company.

CP.* Service Life of Creosoted Pine Poles. *J. A. Fatula*, Virginia Electric and Power Company.

CP.* The Physical Life of Wood Poles. *G. Q. Lumsden*, Bell Telephone Laboratories, Inc.

2:00 p.m. Measurements

CP55-242. Temperature Errors in a Dragmagnet Eddy-Current Disk Type of Tachometer Indicator. *L. T. Akeley* and *J. J. Fraizer*, General Electric Company.

55-150. A New Test Board for Portable Watthour Meter Standards. *F. J. Lewicky*, New England Power Service Company.

55-211. Rapid Measurement of Impedance and Admittance. *B. Salzberg* and *J. W. Marini*, Naval Research Laboratories.

2:00 p.m. Synchronous Machines

CP55-129. New Viewpoints on Old Machines. *G. A. Bekey* and *D. L. Trautman*, University of California.

55-6. A New Approach to the Calculation of Synchronous Machine Reactances—Part 1. *M. E. Talaat*, Elliott Company.

55-130. Stray Losses in the Armature End Iron of Large Turbine Generators. *R. L. Winchester*, General Electric Company.

55-131. Improved Field Conductor Materials for Turbine-Generators. *C. H. Holley* and *R. E. Savidge*, General Electric Company.

55-132. Rewinding A.C. Generators for Improved Performance. *W. G. Saline*, The Shawinigan Water and Power Company.

2:00 p.m. Relays

55-88. Line and Transformer Bank Relaying Systems. *J. L. Blackburn* and *G. D. Rockefeller*, Westinghouse Electric Corporation.

55-99. Some Utility Ground-Relay Problems. *H. C. Barnes*, American Gas and Electric Company and *A. J. McConnell*, General Electric Company.

55-97. Effect of Shock and Vibration on Relays. Project Committee Report.

55-100. Improved Fast Acting Thermal Relay and Its Application as a Cage Winding Protective Relay for Synchronous Machines. *John Baude*, Allis-Chalmers Manufacturing Company.

55-93. Bibliography of Relay Literature—1950–1952. *E. T. B. Gross*, Illinois Institute of Technology. Re-presented for discussion.

2:00 p.m. Electron Equipment Reliability—II

55-154. Machine Testing for Deviation of Data from a Poisson Distribution. *F. A. Haaden*, The Rand Corporation.

CP.* Complexity and Reliability in Automatic Equipment. *Robert Lusser*, Redstone Arsenal.

CP.* The Problem of Measurements Errors. *R. G. Devins*, Eastman Kodak Company.

2:00 p.m. X-Ray Equipment

CP.* Use of Proportional Counters in X-Ray Diffraction. *H. Laird* and *M. J. Zunick*, General Electric Company.

CP.* A.C. X-Ray Tubes. *Z. J. Atlee*, Dunlee Corporation

CP.* Radiation Gages for Inspection and Control. *J. W. Ranftl*, General Electric Company.

CP.* A Survey of Industrial X-Ray Apparatus. *T. H. Rogers*, Machlett Laboratories.

CP.* Multi-Section High Voltage X-Ray and Electron Beam Vacuum Tubes. *G. R. Mahn* and *M. J. Zunick*, General Electric Company.

2:00 p.m. Semi-Conductor Energy Converters

CP.* Properties of P-N Junctions. *W. C. Dunlap, Jr.*, General Electric Company.

CP.* Solar Batteries. *D. M. Chapin*, Bell Telephone Laboratories, Inc.

CP.* Conversion of Nuclear Energy Using P-N Junctions. *J. W. Meyer*, Knolls Atomic Power Laboratories.

CP.* Thermoelectric Generators. *Maria Telkes*, New York University.

55-152. Properties of Silicon Power Rectifiers. *E. F. Lasco*, Westinghouse Electric Corporation. Re-presented for discussion.

2:00 p.m. Power Engineering

55-33. Coordination of Hydro and Steam Generation. *C. W. Watchorn*, Pennsylvania Water and Power Company.

55-185. An Investigation of the Economic Size of Steam-Electric Generating Units. *L. K. Kirchmayer, A. G. Mellor, J. F. O'Mara*, and *J. R. Stevenson*, General Electric Company.

55-184. A Look to the Future of Power Transmission in the West. *H. D. Hunkins*, Bureau of Reclamation. Re-presented for discussion.

Friday, February 4

9:30 a.m. Physics in the Electrical Engineering Curriculum.

CP.* Overall Problem with Special Attention to Pre-college Training. *R. Sueger*, National Science Foundation.

CP.* Point of View of the Electrical Engineering School, Including Graduate Study. *E. Weber*, Polytechnic Institute of Brooklyn.

CP.* The Physics Point of View. *E. Hutchisson*, Case Institute of Technology.

CP.* Physics in Engineering—A Problem in Appraisal. *J. D. Ryder*, Michigan State College.

9:30 am. Basic Sciences

55-126. Equations for the Inductance and Short-Circuit Forces of Three-Phase Busses Comprised of 120° Angles, *J. W. Maier*, Bell Aircraft Corporation and *T. J. Higgins*, University of Wisconsin. Re-presented for discussion

55-156. Junction Transistors Used as Switches. *R. L. Bright*, Westinghouse Electric Corporation.

55-157. Switching Transistors Used as a Substitute for Mechanical Low-Level Choppers. *A. P. Kruper*, Westinghouse Electric Corporation.

55-8. Theory of Magnetic Cross Valves. *W. H. Higa*, Jet Propulsion Laboratories.

9:30 a.m. Transmission and Distribution

55-19. Power Distribution System Parameters. *A. H. Kidder* and *J. H. Neher*, Philadelphia Electric Company.

55-158. Distribution-Substation and Primary-Feeder Planning. *W. J. Denton* and *D. N. Reps*, Westinghouse Electric Corporation.

55-159. A Method for Determining Economical ACSR Conductor Sizes for Distribution Systems. *A. W. Funkhouser* and *R. P. Huber*, Indianapolis Power and Light Company.

55-160. The Use of Probability in the Design and Operation of Secondary Network Systems. *N. M. Neagle* and *D. R. Nelson*, General Electric Company.

55-161. Coincident-Outage Probability in Secondary-Network Vaults. *D. N. Reps*, Westinghouse Electric Corporation.

9:30 a.m. Power Generation

55-162. Production and Installation of Vertical Waterwheel Generators. *W. D. Houser, W. Hindle* and *J. A. Tyerman*, Canadian Westinghouse Company, Ltd.

55-163. Mechanical Alignment of Vertical Shaft Hydroelectric Units as Practiced by Tennessee Valley Authority. *C. L. Norris*, Tennessee Valley Authority.

55-164. Pumped Storage and Hydro-Generation at Flatiron Power Plant. *S. M. Denton* and *H. O. Britt*, Bureau of Reclamation.

55-28. Principles and Application of the Ultrasonic Flowmeter. *R. C. Swengel, S. K. Waldorf*, Pennsylvania Water and Power Company; and *W. B. Hess*, Safe Harbor Water Power Corporation.

55-165. Development of Small Hydro-Electric Sites in Western North Carolina. *H. H. Gnuse, Jr.*, Nantahala Power and Light Company. Re-presented for discussion.

9:30 a.m. Telegraph Systems

55-166. A Portable Telegraph Bias and Distortion Measuring Instrument. *W. D. Cannon*, Western Union Telegraph Company.

55-38. A New Telegraph Serviceboard Using Electronic Circuits. *J. R. Davey, M. R. Purvis*, Bell Telephone Laboratories, Inc.; and *F. H. Hanley*, American Telephone and Telegraph Company.

55-167. A Fully-Selective Telemetering System Employing Telegraph Facilities. *C. W. Smith*, American Telephone and Telegraph Company; and *M. E. Forrest, Jr.*, Southern Bell Telephone and Telegraph Company.

55-94. A New Audio Telegraph Carrier Terminal. *C. A. Higgins* and *E. A. Gilbert*, Radio Frequency Laboratories, Inc.

9:30 a.m. Induction Machines

55-133. Vibration in 2-Pole Induction Motors Related to Slip Frequency. *E. W. Summers*, Westinghouse Electric Corporation.

CP55-134. Noise Reduction in Large Rotating Machines. *J. M. Shulman*, Westinghouse Electric Corporation.

CP.* International Motor Standards. *C. W. Falls*, General Electric Company.

CP55-135. Comments on the NEMA Suggested Standards for Future Design of Integral Horsepower Induction Motors. *F. W. Baumann*, General Electric Company.

CP.* The "How" and "Why" of the Rerate Program. *S. F. Henderson*, Westinghouse Electric Corporation.

9:30 a.m. Instrumentation

55-168. A Survey of Non-Contacting Vibration Pick-ups Using Electric Fields. *H. F. Clarke*, Boeing Airplane Company.

55-23. A Circuit for Measuring the Resistance of Energized A-C Windings. *R. E. Seely*, General Electric Company.

8-68. A Bibliography on Telemetering. AIEE Group Subcommittee on Telemetering. Re-presented for discussion.

CP.* A Glossary of Some Telemetering Terms. October 1954. Report of the Joint AIEE-IRE Subcommittee on Telemetering Terminology.

55-4. Eddy-Current Mutual-Inductance Transducers with High-Conductivity Reference Plates. *H. M. Joseph*, ACF Electronics and *N. Newman*, National Bureau of Standards.

9:30 a.m. Electronic Circuitry

CP.* A Static-Magnetic Data-Storage Unit. *R. H. Fuller*, Massachusetts Institute of Technology.

CP.* An Automatic Random Programmer. *G. A. Roberts*, University of Michigan.

55-197. Cold-Cathode Counting Circuits. *H. L. Foote*, Stromberg-Carlson Company.

55-7. On the Optimum Design of Cathode Followers. *L. M. Vallese*, Polytechnic Institute of Brooklyn.

CP.* Stable Transistor Oscillator. *E. Keonjian*, General Electric Company.

CP55-18. Low Frequency Amplifier Design. *S. I. Rambo*, Westinghouse Electric Corporation.

55-198. Shielding of Communication Cables. *F. H. Gooding* and *H. B. Slade*, The Okonite Company. Re-presented for discussion.

2:00 p.m. Basic Sciences

55-170. Some Properties of Magnetic Fluids. *J. E. Coolidge* and *R. W. Halberg*, Borg-Warner Central Research Laboratory.

55-171. Effects of Transverse Compressional Stress on Magnetic Laminations. *R. E. Fischell*, Naval Ordnance Laboratory.

CP55-172. A Simple Electrical Analogy of Heat Transfer. *F. L. Putzrath*, Radio Corporation of America.

CP.* Accurate Determination of the Capacitance of a Thin Rectangular Plate. *D. K. Reitan* and *T. J. Higgins*, University of Wisconsin.

2:00 p.m. Transmission and Distribution and Protective Devices

55-101. Direct Stroke Protection of High-Voltage Switching Stations and Transformers. *S. B. Grizzom, J. K. Dillard* and *A. R. Hileman*, Westinghouse Electric Corporation.

55-136. Transient Durability Testing of Valve Type Lighting Arresters. *J. W. Kalb* and *A. G. Yost*, Ohio Brass Company.

CP.* Surge Attenuation in Power Cables. *W. W. Valentine*, Potomac Electric Company, *J. K. Dillard, J. M. Clayton*, Westinghouse Electric Corporation.

CP55-137. Analysis of Gradient Data Under Thunder Clouds. *J. F. H. Douglas*, Marquette University.

2:00 p.m. Power Generation

55-96. Transfer of Steam-Electric Generating Station Auxiliary Buses. *D. G. Lewis* and *W. D. Marsh*, General Electric Company.

CP55-92. Transfer Tests on Station Auxiliary Buses. *L. E. Backer, P. Barth, R. A. Huss* and *D. W. Taylor*, Public Service Electric and Gas Company.

55-173. Maximum Short Circuit and Faulty Synchronizing Torques on Generator Foundations. *V. W. Ruskin*, Canadian-Brazilian Services, Ltd. Re-presented for discussion.

2:00 p.m. Telegraph Facsimile Systems

55-174. Textile Automation by Signal Control. *Louis Casper*, Electrotext Corporation.

CP55-175. A Polar Relay Using Momentum Transfer. *H. L. Garbarino* and *K. E. Bisshopp*, Armour Research Foundation of Illinois Institute of Technology.

CP.* Electrolytic Recording for Facsimile. *J. W. Smith, A. H. Mones* and *J. V. L. Hogan*, Hogan Laboratories, Inc.

CP.* Times Facsimile Recording Papers. *H. R. Dalton* and *A. G. Cooley*, Times Facsimile Corporation.

2:00 p.m. Dielectric Measurements

55-176. Progress in the Evaluation of Solid Core High Voltage Bushings. *H. H. Brustle, D. L. Johnston* and *A. L. Scheideler*, General Electric Company.

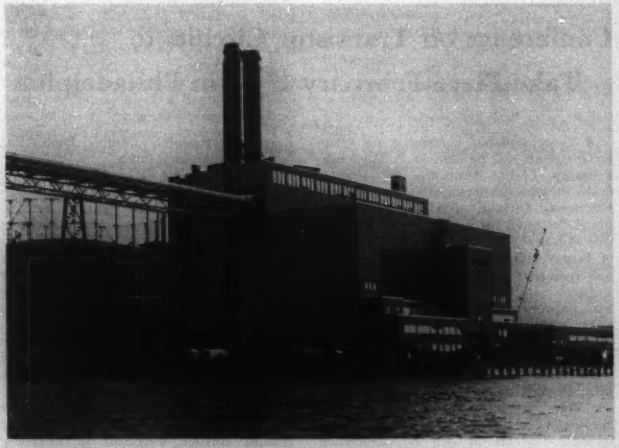
CP.* Corona Tests in the Field on High Voltage Insulation. *F. C. Doble, F. S. Oliver* and *E. H. Povey*, Doble Engineering Company.

CP.* Corona Studies—In Relation to Insulation. *T. W. Liao, J. R. Nye, J. G. Anderson* and *H. H. Brustle*, General Electric Company.

CP55-235. Measurement Pitfalls Encountered in D-C Dielectric Testing in the Field. *C. W. Ross* and *E. B. Curdts*, James G. Biddle Company.

CP55-236 Report of Dielectric Tests on a Large Hydro-Generator. *C. A. Duke*, Tennessee Valley Authority; *C. W. Russ*, James G. Biddle Company; and *J. S. Johnson*, Westinghouse Electric Corporation.

CP55-16. A Versatile High Voltage D-C Insulation Tester. *H. T. McLean*, General Electric Company.



Shown above is the Astoria Generating Station of Consolidated Edison Company of New York. There are two 13-story high boilers to provide high-pressure steam for the two 180,000-kw cross compound turbine generators. The boilers are equipped to burn coal, oil, or natural gas. This station is also on the list of inspection trips during the Winter General Meeting

(*Continued from page 67*)

Sunday, January 30, from 2:00 to 4:00 p.m., and thereafter each day beginning at 8:30 a.m. in the Ladies' Headquarters.

ETA KAPPA NU AWARD DINNER

The Annual Recognition Award Dinner of the Eta Kappa Nu Association for the Outstanding Young Electrical Engineer of 1954 will be held Monday evening, January 31, 1955, in the Tudor Room of the Henry Hudson Hotel. The Award will be presented to Dr. Ruben F. Mettler of Hughes Aircraft Company. Dr. Mettler is now temporarily in Washington as Special Consultant to the Secretary of Defense. Honorable Mention citations will be presented to E. E. David, Jr., of Bell Telephone Laboratories, and Linden E. Saline, L. K. Kirchmayer and J. F. Fuller, all of the General Electric Company.

Winners of the award were selected on their meritorious service in the interest of their fellow men as evidenced not only by outstanding technical achievement but also by their civic and social activities, cultural and aesthetic development, and participation in outside activities. Selection was made by a jury consisting of Ralph Bown, Bell Telephone Laboratories; L. R. Gaty, Philadelphia Electric Company; E. M. Strong, Cornell University; G. Edward Pendray, Pendray and Company; E. T. B. Gross, Illinois Institute of Technology; and Reid Warren, University of Pennsylvania.

All AIEE members and guests, including the ladies, are invited to this event. Reservations should be sent to E. F. Schuster, Treasurer, 117-08 109th Avenue, South Ozone Park 20, N.Y., with checks payable to the New York Alumni Chapter, Eta Kappa Nu. Charge will be $5.00 per person.

WINTER GENERAL MEETING COMMITTEE

Members of the 1955 Winter General Meeting Committee are: A. J. Cooper, chairman; D. M. Quick, vice-chairman; J. J. Anderson, secretary; C. S. Purnell, budget co-ordinator; J. P. Neubauer, vice-president, District 3; J. D. Tebo, chairman, Committee on Technical Operations; R. T. Ferris, public relations; J. R. Kerner, general session; Avery Gould, dinner-dance; W. G. Vieth, hotel accommodations; J. V. O'Connor, inspection trips; Morris Brenner, registration; R. W. Gillete, smoker; R. T. Weil, monitors; S. Friend, Jr., theater and broadcast tickets; Mrs. Merwin Brandon, ladies' committee; C. T. Hatcher, ex officio member (past-chairman).

Engineering Societies Library Welcomes Members' Visits

Members and others attending the Winter Meeting of the Institute are especially invited to visit the Engineering Societies Library in the Headquarters building at 33 West 39th Street in New York City.

The Engineering Societies Library has an outstanding collection of electrical engineering literature. Its 170,000 volumes also cover all fields of engineering, primarily on the level of the graduate and practicing engineer. Student members find the Engineering Societies Library collection useful as it supplements those of the engineering schools.

The Reading Room of the Library is now open Mondays through Fridays, 10:00 a.m. to 9:00 p.m. and Saturdays 10:00 a.m. to 6:00 p.m. Why not take this opportunity to visit the Institute's Library to learn how it can serve you by mail, telephone, or telegraph, as well as in person?

Conference on Transistor Circuits to Take Place February 17-18 in Philadelphia

A 2-day national conference on transistor circuits will be held in Philadelphia, February 17–18, Thursday and Friday, under the joint sponsorship of the Science and Electronics Division of AIEE, the Professional Group on Circuit Theory of the Institute of Radio Engineers, and the University of Pennsylvania. The 1955 Conference is patterned after the first one held a year ago.

There will be four consecutive sessions with papers covering both linear and nonlinear transistor circuit applications. Emphasis will be on material not previously available in the literature, and the program is designed to be of greatest value to engineers who already possess some knowledge of transistor circuit behavior. Authors are encouraged to publish subsequently in professional journals in lieu of Conference Transactions.

One innovation being considered is a Thursday evening session of informal round-table discussions. It is requested that those interested in participating write the Program Committee chairman, Mr. H. E. Tompkins, Burroughs Research Center, Paoli, Pa., indicating discussion topics.

Host for the conference is the University of Pennsylvania which has made Irvine Auditorium available for all technical sessions. Lunch will be served for a limited number at nearby Houston Hall on both Conference days. An informal cocktail-buffet, followed by the round-table discussions on Thursday evening, will take place at the Penn Sherwood Hotel. This hotel is also reserving a block of rooms for out-of-town registrants. Advance registration is encouraged, since facilities available for the Conference are limited and final plans will be based on the number of advance registrants.

Forms for advance registration have been mailed to all members of the sponsoring groups. Anyone interested in attending who has not received these forms by January 15 should request them from W. J. Popowski, Minneapolis-Honeywell Regulator Company, 176 West Loudon Street, Philadelphia 20, Pa. The tentative technical program follows.

Thursday, February 17

Morning. Session I. Oscillators

Chairman: J. J. Suran, General Electric Company

Transistor Superregenerative Detection. *W. F. Chow*, General Electric Company

Field-Effect Transistor Applications. *C. Huang, M. Marshall, L. B. White*, Sylvania Electric Products, Inc.

A Stabilized Transistor Oscillator. *E. Keonjian*, General Electric Company

A Symmetrical Transistor Oscillator with Low Second-Harmonic Distortion. *W. M. Grim, Jr.*, Massachusetts Institute of Technology

Afternoon. Session II. Linear Systems

Chairman: R. B. Adler, Massachusetts Institute of Technology

Predictions Based on the Maximum Oscillator Frequency. *P. Drouilhet*, Philco Corporation and Massachusetts Institute of Technology

Principles of Automatic Gain Control of Transistor Amplifiers. *W. F. Chow, A. P. Stern*, General Electric Company

A Transistor Transmitter-Receiver Unit. *C. C. Bopp*, Crosley Division of AVCO Manufacturing Corp.

A Transistor Amplifier and Discriminator with Bias Stabilization. *T. A. Patchell*, Minneapolis-Honeywell Regulator Company

Friday, February 18

Morning. Session III. Digital-Computer Circuits

Chairman: Richard Endres, Radio Corporation of America

Junction-Transistor Flip-Flops with Differential-Transformer Coupling. *Howard Kennedy, A. B. Jacobsen*, Motorola, Inc.

A Multistable Transistor Circuit. *R. A. Henle*, International Business Machines Corp.

Transistors in Computer Circuits. *D. E. Dewitt*, Radio Corporation of America

Transistor Plug-In Units for Digital Computing Systems. *R. H. Baker*, Massachusetts Institute of Technology.

The Regeneration Analysis of Junction-Transistor Multivibrators. *D. O. Pederson*, Bell Telephone Laboratories, Inc.

Afternoon. Session IV. Large-Signal Operation

Chairman: Robert Mayer, Minneapolis-Honeywell Regulator Company

Junction-Transistor Circuits for Analogue-to-Binary Code Conversion. *F. H. Blecher*, Bell Telephone Laboratories, Inc.

A Temperature-Compensated Transistor Power Converter. *C. E. Paul*, Bell Telephone Laboratories, Inc.

Transistors as Power-Conversion Devices. *R. R. Smyth*, Technical Operations, Inc.

Power-Transistor Switching Circuits. *E. Slobodzinski, C. Huang*, Sylvania Electric Products, Inc.

An N-Stage Series Transistor Circuit. *K. H. Beck*, Minneapolis-Honeywell Regulator Company

IRE's New York Section to Sponsor Transistor Circuit Symposium

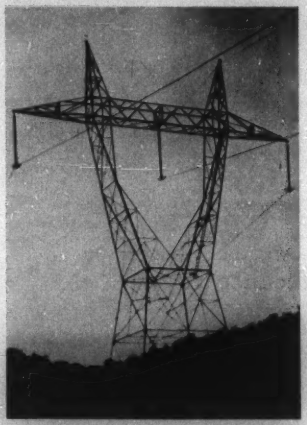
The Institute of Radio Engineers' (IRE) New York Section will sponsor a symposium, "Design Principles of Transistor Circuits," January 8, 9:45 a.m., at the Engineering Societies Building, 33 West 39 Street, New York, N. Y. There will be seven speakers and a round-table discussion. Dr. John G. Linvill of Bell Telephone Laboratories will be moderator. Registration fee for IRE members is $2.00, for nonmembers $4.00, and student members are admitted free.

Three-Day Meeting Planned for Utilization of Aluminum Conference

Application of aluminum in electric equipment and in transmission and distribution systems, reports on experience with aluminum conductors, and inspection trips of plants in the local Pittsburgh area are planned for AIEE's Electrical Utilization of Aluminum Conference. This meeting will take place on March 15, 16, and 17, 1955, at the William Penn Hotel, Pittsburgh, Pa.

The local Pittsburgh committee is working with Mr. B. G. A. Skrotzki of *Power Magazine*. Mr. C. T. Hatcher, Consolidated Edison; and Mr. R. S. Gardner of the Institute's headquarters staff. Committee chairman is R. N. Wagner of the Aluminum Company of America.

Committee members are: A. C. Ocker, Bell Telephone Company; J. E. Lange, Duquesne Light Company; W. H. Osterle, West Penn Power Company; E. W. Brewer, General Electric Company; R. F. Lawrence, and D. N. Reps of Westinghouse Electric Corporation; and J. Z. Linsenmeyer, also of Westinghouse Electric Corporation.



In the illustration an aluminum conductor for transmission of extra-high-voltage power is outlined against the sky. User reports on experience with aluminum conductors are planned as part of the 3-day Utilization of Aluminum Conference to take place next March.

Engineers Joint Council to Hold First Open General Assembly, January 21

The First General Assembly of Engineers Joint Council (EJC) will be held January 21, 1955, in the Hotel Statler, New York, N. Y. The basic theme of the meeting will be the increase of unity in the profession. Forums will be held on nuclear developments, employment conditions, manpower, and EJC objectives.

Admission to the forums will be by tickets, without charge and available at the door. Luncheon and banquet tickets will be $4.50 and $7.50, respectively, and may be obtained from EJC's secretary in advance or at the door if available.

Proceedings will begin at 9:30 a.m. and run through the evening. Thorndike Saville, Dean of Engineering, New York University, and Council president, will preside. Dr. John R. Dunning, Dean of Engineering, Columbia University, will be chairman of an open forum on nuclear developments as they affect the engineering profession, including the proposed Nuclear Engineering and Science Congress scheduled for 1955. He is general chairman of the EJC's new Operating Committee for Nuclear Engineering and Science.

A panel on "Employment Conditions and Unionization—Their Effect on the Engineer" will be headed by G. Brooks Earnest, president of Fenn College, Cleveland, Ohio, and former vice-president of the American Society of Civil Engineers. Other panel members and their subjects are: Arthur K. Doolittle, assistant director of research, Carbide and Chemical Corporation: "Engineering—A Profession"; Nathan W. Dougherty, Dean of Engineering, University of Tennessee: "Is Collective Bargaining Compatible with Professionalism?"; E. Lawrence Chandler, EJC treasurer and assistant secretary of the American Society of Civil Engineers: "Responsibility of Management and the Employee in the Engineering Profession." The panel meeting will include an open discussion on the background and current developments in connection with the question of unionization of engineers.

Luncheon speaker will be John F. Hilliard, of Washington, D. C., Deputy Assistant Director for Manpower, Office of Defense Mobilization. His subject will be, "Engineers and Our National Well-Being." The first afternoon forum will be on engineering manpower. Chairman of this forum will be Dr. Thomas H. Chilton, technical director, E. I. du Pont de Nemours and Company, past-president, American Institute of Chemical Engineers, and chairman of the Engineering Manpower Commission.

Another forum discussion in the afternoon will be "The EJC Objectives." Panel participants will include Carlton S. Proctor, chairman, past-president, American Society of Civil Engineers; Dr. Harold S. Osborne, consulting engineer; Clarence E. Davies, secretary, American Society of Mechanical Engineers.

EJC's First General Assembly will close after a banquet which will be addressed by AIEE Past-President Donald A. Quarles, Assistant Secretary of Defense for Research and Development.

The prospect of new member societies has been advanced by action of the Board to invite eligible organizations to apply for associate or affiliate membership under conditions provided in recent amendments to the EJC constitution. Under prescribed conditions the admission of national and local organizations, heretofore not eligible, is possible. One of the qualifications for constituent membership is a national society roster of at least 5,000. An amendment now permits admission as associates of national organizations having less than 5,000. The other amendment permits admission as affiliates of societies that are regional, rather than national, in geographic scope. In each instance, admission would be without vote, but provision is made for participation in Council meetings.

AIEE Nominating Committee Will Meet in New York City

The Nominating Committee of the AIEE will meet in the Hotel Statler, New York, N. Y., January 31, 1955, during the Winter General Meeting of the Institute to nominate candidates for AIEE offices to be voted on by the membership in the spring of 1955. Members of the committee are as follows:

Representing the Board of Directors:

D. I. Cone, Pacific Telephone and Telegraph Company, San Francisco, Calif.

D. D. Ewing, Purdue University, Lafayette, Ind.

E. S. Lammers, Jr., Westinghouse Electric Corporation Atlanta, Ga.

J. P. Neubauer, Consolidated Edison Company of New York, Inc., New York, N. Y.

E. W. Seeger, Cutler-Hammer, Inc., Milwaukee, Wis.

Alternates:

G. J. Crowdes, Simplex Wire and Cable Company, Cambridge, Mass.

J. H. Foote, Commonwealth Services, Inc., Jackson, Mich.

A. C. Muir, Berwind-White Coal Mining Company, Philadelphia, Pa.

Representing the ten geographical districts:

1. E. K. Rohr, General Electric Company, Lynn, Mass.

2. J. C. Strasbourger, Cleveland Electric Illuminating Company, Cleveland, Ohio

3. J. R. Kerner, Westinghouse Electric Corporation, New York, N. Y.

4. H. B. Wolf, Duke Power Company, Charlotte, N. C.

5. J. R. North, Commonwealth Associates, Inc., Jackson, Mich.

6. M. H. Kight, U. S. Bureau of Reclamation, Denver, Colo.

7. M. H. Lovelady, Central Power and Light Company, Corpus Christi, Tex.

8. Charles R. Day, Sacramento Municipal Utility District, Sacramento, Calif.

9. W. H. Mott, 1203 West Woolman Street, Butte, Mont.

10. P. J. Croft, Canada Wire and Cable Company, Toronto, Ont., Canada

Alternates:

1. R. Curts, Jr., General Electric Company, Schenectady, N. Y.

2. H. H. Sheppard, Rumsey Electric Company, Philadelphia, Pa.

3. R. T. Weil, Jr., Manhattan College, New York, N. Y.

4. P. R. Spracher, Virginia Electric and Power Company, Richmond, Va.

5. W. L. Cassell, Iowa State College, Ames, Iowa

6. J. O. Kammerman, South Dakota School of Mines and Technology, Rapid City, S. D.

7. J. L. Pratt, Allis-Chalmers Manufacturing Company, Dallas, Tex.

8. M. N. Davis, Sacramento Municipal Utility District, Sacramento, Calif.

Representing the five technical divisions:

Communications: H. A. Affel, Bell Telephone Laboratories, Inc., Murray Hill, N. J.

General Applications: L. W. Birch, Ohio Brass Company, Mansfield, Ohio

Industry: G. W. Heumann, General Electric Company, Schenectady, N. Y.

Power: B. G. A. Skrotzki, associate editor, *Power*, New York, N. Y.

Science and Electronics: S. Reid Warren, Jr., Univ. of Pennsylvania, Philadelphia, Pa.

Alternates:

Communications: F. B. Bramhall, Western Union Telegraph Company, New York, N. Y.

General Applications: R. L. Oetting, General Electric Company, Cleveland, Ohio

Industry: C. N. Clark, Duquesne Light Company, Pittsburgh, Pa.

Power: C. T. Hatcher, Consolidated Edison Company, New York, N. Y.

Science and Electronics: J. G. Reid, Jr., A.C.F. Industries, Inc., Alexandria, Va.

Western Computer Conference Is Set for March 1-3 in Los Angeles

The Western Computer Conference and Exhibit will be held at the Statler Hotel, Los Angeles, Calif., March 1, 2, and 3. Sponsors are: AIEE, Institute of Radio Engineers, and the Association for Computing Machinery.

Theme of the conference is "Functions and Techniques on Analogue and Digital Computers." Technical papers and discussions will include descriptions of existing systems and techniques, language and communication problems between machines, the possibilities of managerial and computer systems revision to achieve rapid integration, and new developments in analogue computers and analogue computing methods. The exhibit will be limited to the products of manufacturers who make computers or major computer subassemblies and will be open during day and evening hours so that all may visit. In addition to the technical sessions and exhibit, there will be evening field trips to major Los Angeles electronics firms, a cocktail party, and luncheons.

Pre-registration fee is $2.50 and covers admittance to lectures and exhibits and a copy of the Proceedings. Those interested in attending should write: William Gunning, Conference Secretary, International Telemetering Corporation, 2000 Stoner Avenue, Los Angeles 25, Calif.

Conference on Electrical Techniques in Medicine and Biology Held in Chicago

Sponsored jointly by AIEE, the Institute of Radio Engineers, and the Instrument Society of America, the Seventh Annual Conference on Electrical Techniques in Medicine and Biology was held Nov. 10–12, 1954, at the Morrison Hotel, in Chicago. More than 150 participants were in attendance. This was the seventh time that electrical engineers and electronics experts met with researchers in the fields of medicine, biology, and biophysics to exchange viewpoints and discuss problems of mutual interest.

Conferees were given a look into latest developments in electrocardiography in a symposium under the chairmanship of Dr. Samuel Talbot of Johns Hopkins University, School of Medicine. Dr. Otto Schmide, University of Minnesota, was chairman for a session devoted to electrical properties of biological materials, and Dr. J. W. J. Carpender of the University of Chicago for a session on new developments in X-rays and instrumentation. Among the many new techniques discussed were: a process for making X-ray pictures without using film; apparatus for increasing fluoroscopic image brightness by a factor of 40,000; and X-ray motion pictures requiring greatly reduced radiation dosage.

Dr. T. E. Allibone (left) was guest speaker at the Conference. He is director of research, Associated Electrical Industries, Great Britain. Dr. E. D. Trout, general chairman of the Conference is on the right

Outstanding events were: an address at the November 10 dinner meeting by Dr. T. E. Allibone, on electromedical research in Great Britain; tours of the Argonne Cancer Hospital, and of the biology section of the Argonne National Laboratory, where conferees learned about many of the latest physical and electrical research activities in medicine and biology.

ASME Deputy Secretary Retires After 43 Years of Service

Ernest Hartford, 71, has retired as deputy secretary of The American Society of Mechanical Engineers (ASME) after 43 years of service to that organization. He will continue to serve in a consulting capacity.

In 1903, Mr. Hartford became secretary to A. L. Williston, director of Pratt Institute, Brooklyn, N. Y. Besides routine duties of the executive office of a technical school, he was active in the work of the Society for the Promotion of Engineering Education and the Society for the Promotion of Industrial Education, both of which he served as secretary.

This work was primarily responsible for his selection, in 1911, as assistant to the secretary of The American Society of Mechanical Engineers (ASME). When he first joined ASME, the society had a membership of approximately 4,000. Sectional activity of the organization was limited. With the late Dr. Calvin W. Rice, then secretary of ASME, Mr. Hartford began development of plans for increasing membership, handling applications for admission to membership, and expansion of sectional and student activities.

From 1919 on, he supervised the ASME staff, society meetings, Professional Division, society awards, student branches, admissions, membership development, honors, Toltz Awards and Educational Committee. He has been field manager of the Society and, as executive assistant secretary, was in charge of ASME headquarters during the absence of the secretary for service in World War II.

During World War I, Mr. Hartford was granted a leave of absence to serve as office manager in charge of the executive offices for the War Department's Committee on Education. Operations of the Committee included training of 330,000 men for service in the U. S. Army overseas as mechanics, machinists, sheet metal workers, and other technical activities, and the organization of college men into the Student Army Training Corps. He became an ASME Affiliate Member in 1918, full Member in 1950, and a Life Member in 1952.

More than 200 Attend Atlantic Textile Conference, November 4-5, in Raleigh, N. C.

Over 200 electrical engineers, plant engineers, and textile mill representatives were at North Carolina State College in Raleigh, N. C., for the Atlantic Textile Conference, November 4–5.

An annual event at the college, the conference was sponsored by the Textile Subcommittee and the North Carolina Section of AIEE, North Carolina State College's Department of Electrical Engineering, and the college's School of Textiles. This year's conference had for its theme, "Electronics and Maintenance." These two subjects were chosen by the audience at the close of last year's conference.

Since registration and a tour of the School of Textiles took place during the morning of the first day, visitors to the conference could arrive any time in the morning without missing any conference proceedings. In the afternoon, the subject was "Electronics." Dr. G. B. Hoadley, head of the Electrical Engineering Department, North Carolina State College, delivered introductory remarks on basic industrial electronics.

On the following day, Friday, the morning was given to presentation of various papers beginning with electric heat applied to textile process drying, designing for reduced maintenance, trouble-shooting on motors, and reports by the Conference Committee and the joint NEMA-AIEE Textile Committee on enclosures.

The afternoon session dealt with maintenance of electronic control equipment both in knitting and weaving mills. As in past years, this included a panel discussion of electrical problems and their remedies. Most of the participation comes from the audience in this session.

W. W. Hammond of the Okonite Company, Charlotte, N. C., was general chairman of the Conference Committee. He was ably supported by AIEE Textile Subcommittee chairman V. F. Sepavich of the Crompton and Knowles Loom Works, Worcester, Mass., and Dr. J. H. Lampe, Dean of the School of Engineering, North Carolina State College

Registrants for the Atlantic Textile Conference were taken care of by electrical engineering students at North Carolina State College. Standing at desk are: John Morrison and Don Hannasch, both of Minneapolis-Honeywell Regulator Company

IRE Adds Building to House 1955 Radio Engineering Show

Seven hundred radio and electronic firms will exhibit in the Institute of Radio Engineers' (IRE) 1955 Radio Engineering Show, a gain of 16 per cent over 1954. This expansion, which is needed to keep pace with the growing radio industry, has been made possible by the addition of exhibits in Kingsbridge Palace, a large skating rink in New York City. Dates are March 21 to 24.

Even the huge, 4-acre Kingsbridge Armory, and the Palace which often accommodates over 2000 skaters, will not satisfy the exhibit demands of this booming industry. IRE has scheduled its 1956 Convention in the New York Coliseum and has booked its entire facilities. It is the first definite booking for the gigantic four-floored exhibition hall scheduled for completion March 1, 1956.

The Kingsbridge Palace provides 100 exhibit units. Three hundred and fifty yards away from the Kingsbridge Armory Entrance, it will be serviced by free busses that will circle each building and the parking areas at 5 minute intervals. Also, 16 busses on expanded service to the Waldorf Astoria Hotel will stop at both the Palace and the Armory.

Kingsbridge Armory provides two large lecture halls for technical sessions. At the Waldorf Astoria, the Ballroom and four smaller halls will house the rest of the sessions. More than 200 papers sponsored by 22 IRE professional groups will be presented, covering new developments of radio-electronic engineering and research.

Slightly less than 40,000 registered at the 1954 convention, and George W. Bailey, IRE executive secretary expects almost 10 per cent more members and visitors in 1955.

Group picture above was taken at the Atlantic Textile Conference, November 4–5, at North Carolina State College in Raleigh, N. C. First row (left to right): F. D. Snyder, Westinghouse Electric Corporation; J. D. McConnell, Cone Mills Corporation; V. F. Sepavich, Crompton and Knowles Loom Works; W. W. Hammond, The Okonite Company. Standing (left to right): J. H. Lampe, Dean, School of Engineering, North Carolina State College; H. S. Colbath, Ribb Manufacturing Company; S. Cowan, Factory Insurance Association; A. W. Frankenfield, E. I. du Pont de Nemours and Company; R. R. Prechter, General Electric Company; J. T. Meador, Southern Electric Service Company; M. R. Brice, Cutler-Hammer, Inc., R. H. Clark, Warner and Swasey Company; C. E. Robinson, Reliance Electric and Engineering Company

Communication "Miracles" Seen By North Carolina Members

"Miracles are ahead in the field of communications," according to C. E. Schooley, chief engineer, Southern Bell Telephone and Telegraph Company. Mr. Schooley spoke to 200 members at the North Carolina Section's fall meeting, November 19, on the North Carolina State College campus, Raleigh, N. C. He predicted more advancements will be made in communications during the next decade than have been made since the beginning of World War I.

Mr. Schooley demonstrated nation-wide, long-distance dialing by phoning telephone company officials in San Francisco and Montclair, N. J., direct from the college dining hall. He also showed a device that will answer the telephone and leave a message during the absence of the business man from his office or the housewife from her home.

In previewing things to come in the telephone industry, Mr. Schooley demonstrated a hands-off telephone which may be used by punching a dial to get a number and listening to the response by means of a small speaker which brings the message not only to the person making the call, but to others in the room as well.

After an address of welcome given by Dr. J. H. Lampe, dean of engineering at the College, a paper entitled "The Next Decade in Power" was presented by A. S. Griswold, assistant to the president, Detroit Edison Company. W. R. Harris, manager of the industrial engineering department, Westinghouse Electric Corporation, Pittsburgh, Pa., gave a talk on the next decade in power utilization equipment in industry; and Dr. Louis T. Rader, general manager, specialty control department, General Electric Company, Schenectady, N. Y., spoke about automatic controls for industrial processes. Also on the program were two Duke University engineering students: Charles E. Seagar and Edward V. Stephenson. They presented a paper, "Fluid Mapping of Electric and Magnetic Fields."

Highlight of the meeting was the presentation of a certificate and pin to Charles R. Vail of Duke University, Durham, N. C., in recognition of his service as past Section chairman. Charles Almon of the Tennessee Valley Authority, Chattanooga, Tenn., District vice-president, presented the award.

K. T. Knight of William C. Olsen and Associates, Raleigh, was chairman of the Program Committee. Working with him was W. C. Burnett, Southern Bell Telephone and Telegraph Company, Charlotte, N. C.; W. J. Wortman, Duke Power Company, Charlotte; A. J. Hill, General Electric Company, Raleigh; J. C. Bregan, Western Electric Company, Winston-Salem; and R. W. Foster, Champion Paper and Fibre Company, Canton.

Composing the Section's Executive Committee are: Chairman H. W. Oetinger, K. T. Knight, G. L. Peeler, C. R. Vail, W. F. Sanders, R. E. Lawrence, R. W. Foster, J. C. Bregar, A. J. Hill, and W. J. Wortman.

Missouri Mines Branch Plays Host at Banquet

The Missouri School of Mines played host, November 5, to the student branches of St. Louis, Washington, and Missouri Universities, as well as to members of the St. Louis Professional Section. One-hundred ten persons attended the banquet at the College Inn of the Hotel Edwin Long.

After dinner, Campbell Barnds, chairman of the Missouri Mines Branch, introduced guests at the speakers table. Among these were department heads, chairmen and counselors of various branches.

Speaker of the evening was G. F. Maughmer, who is manager of the Mid-States District Apparatus Sales Division, General Electric Company. His paper was entitled, "A Richer Tomorrow Through Electricity." With the aid of slides, he told the audience of future possibilities in the electrical industry.

AIEE Employment Questionnaire Brings Large Response

On September 15, 1954, questionnaires were mailed to 44,095 AIEE members in continental United States, asking for information and opinions on employment conditions. Over 25,000 responses, or 57 per cent have been received.

As this issue of *Electrical Engineering* goes to press, these returns have been recorded on punched cards and given a first run through the tabulating machine to get an over-all count. This gross count shows that the geographical distribution of the response checks closely with the membership as a whole. All grades of membership and age groups appear to be well-represented insofar as data are available for comparison.

The response to Question 12, which invited additional comment by the respondent, was most gratifying in that 7,243 members (more than 29 per cent) expressed personal opinion in from 25 to several-hundred words. These opinions are being classified and tabulated and will be made the topic of future discussions on the subject. Reading and classifying these comments has taken, sofar, the full time, for two weeks, of a special committee of three working under the supervision of the Committee on Planning and Co-ordination. Further study and analysis of these is planned.

In his letter to the AIEE membership, transmitting the questionnaire, President Monteith said: "The facts you provide and the opinions you express in your answers will be added up, analyzed, and combined with the results of similar surveys being conducted by some of the other major societies. The combined results will then be available for the guidance of legislators and others who should know what engineers want before taking action that affects the profession and the welfare of its individual members."

The project was undertaken by the 1953–54 Committee on Planning and Co-ordination under the chairmanship of F. O. McMillan. It is being completed by the 1954–55 Committee, of which Mr. L. F. Hickernell is chairman. The Committee feels that the response of the members has been excellent and that valuable data have been obtained for the purposes outlined by the President.

Electrical Engineer Has Invented "Perpetual Calendar"

Two legislatures, Hawaii and Massachusetts, have endorsed "The Perpetual Calendar," invented by AIEE member Willard Edwards. Mr. Edwards is branch manager of the Maintenance Engineering Division, Electrical Branch, District Public Works Office, 14th Naval Office, Pearl Harbor, Hawaii. It is the only calendar proposal which has been endorsed by any branch of our Government, and Mr. Edwards now hopes for international adoption. At present

Willard Edwards

Strong interest in North Carolina Section's Fall Meeting was displayed when more than 200 engineers attended technical sessions at North Carolina State College, November 19. The crowd shown at left was typical of the number of engineers at the sessions

JAN - APR - JUL - OCT						
Mon	Tue	Wed	Thu	Fri	Sat	Sun
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

FEB - MAY - AUG - NOV						
Mon	Tue	Wed	Thu	Fri	Sat	Sun
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

MAR - JUN - SEP - DEC						
Mon	Tue	Wed	Thu	Fri	Sat	Sun
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

With the Perpetual 12-Month Calendar, each quarter and each year is the same. New Year's Day, a day apart from any week or month, precedes Monday, January 1, and is the first day of each year, an international holiday and the third day of a 3-day week end. It is followed by the 364-day fixed calendar shown above, with three complete months in each quarter. Leap-Year Day, a second day apart, is observed in leap years between June 31 and July 1. It then becomes the first day of the second half-year, a new international holiday. Mr. Willard Edwards, inventor of the calendar, invites support of this plan by writing to Congress and the United Nations requesting its adoption

it is among various documents on calendar reform submitted to a United Nations Committee for study early this year.

"The Perpetual Calendar" begins with "New Years Day" as a day apart. It is followed by Monday, January 1, and it has 26 working days in each month, plus Sabbaths or rest days. The first and fifteenth of all months fall on weekdays, Christmas and other proposed holidays fall on Mondays, and there are no "unlucky" Fridays-the-thirteenth. It may be printed with either Sunday or Monday as the first day of the week as is now often done in Austria, Spain, and other countries.

The months always begin on significant weekdays, Monday, Wednesday, and Friday; and each quarter has 91 days with three complete months of 30, 30, and 31 days.

A rhyme that may replace the old "Thirty Days Hath September" verse, if Mr. Edward's calendar receives official international endorsement follows:

"With a day apart, the year is begun,
Then follows thirty, thirty, thirty-one:
Months always start a certain way,
On Monday, Wednesday and Friday:
Each quarter and each year the same
Is The Perpetual Calendar aim."

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Communication Division

Committee on Radio Communications Systems (*E. D. Becken, Chairman; R. D. Campbell, Vice-Chairman; David Talley, Secretary*). The overlapping of interest with the Institute of Radio Engineers (IRE) for papers in the radio communication field was discussed at some length at the Committee meeting during the Fall General Meeting in Chicago. It was thought that this Committee might make a special effort to sponsor papers covering design and operations of over-all communications systems as such, since so many IRE papers covered the design of specific units of communication equipment.

An attempt will be made to secure papers covering operation of foreign communication systems. Efforts are also being made to develop a series of papers on the use of very-high frequencies and ultra-high frequencies for long-distance radio communications by means of tropospheric scattering.

Arrangements have been made whereby the Committee chairman acts as liaison with the Standards Committee on radio communication matters. In addition, separate standards liaison has been provided for the problem of electrical distribution and associated generation of radio noise.

Industry Division

Committee on Electronic Power Converters (*August Schmidt, Jr., Chairman; J. B. Pitman, Vice-Chairman; J. K. Dillard, Secretary*). This Committee has been recently transferred from the Science and Electronics Division to the General Industry Division. This move brings it into closer proximity with other committees which have an interest in electronic power converters. Papers sponsored by the committee will appear in the publication having the largest audience of interested readers.

The committee made material contributions to the sessions of International Electro-Technical Commission Mercury-Arc Rectifier Subcommittee 22–1 at the conference in Philadelphia during September. Several Committee members attended the sessions as delegates. American recommendations for the session were formulated by a Committee working group.

Committee on Industrial Power Systems (*S. A. Warner, Chairman; R. H. Whaley, Vice-Chairman; R. T. Woodruff, Secretary*). Three subcommittees are in various stages of work on publications. The Subcommittee on Industrial Grounding has submitted its material to the AIEE Standards Committee for a publication, "Grounding of Industrial Power Systems" as a recommended guide.

The Subcommittee on Electric Power Distribution for Industrial Plants, working on the revision of the "Red Book" of the same name is in the stage of committee review preparatory to referring the material to the AIEE Standards Committee.

The Subcommittee on Distribution Systems for Commercial Buildings is being organized into working groups for the revision of the existing special publication, "Interior Wiring Design for Commercial Buildings" for consideration as a recommended guide by the Standards Committee under the title of "Electric Distribution Systems for Commercial Buildings."

Power Division

Committee on Protective Devices (*E. G. Norell, Chairman; E. M. Hunter, Vice-Chair-*

Maryland Section to Celebrate 50th Anniversary

Maryland Section's Fiftieth Anniversary Committee took time out to have this picture taken. The Committee has been busy making preparations for a Golden Anniversary Dinner-Dance, at the Sheraton Belvedere Hotel, Baltimore, on January 22. Dr. J. B. Whitehead (see Obituary, page 85), National President (1933–34) organized the Section. Past chairmen will be honored at the meeting

South West Executive and Student Committee Meetings

Good attendance at the South West Executive Committee's Fall Meeting is indicated by the above picture. The meeting was held in Fort Worth, Texas, November 18. Presiding was AIEE Vice-President S. M. Sharp (seated, third from left). To the right of Sharp is Past AIEE President Elgin B. Robertson (1953–54), and to his right is Past AIEE Vice-President C. M. Lytle (1952–54)

At left are shown Institute officers meeting with Student Branch counselors of the South West District in Fort Worth, Texas, November 19, 1954. E. L. Sitz was chairman. W. C. Morris, District Secretary, acted as secretary for the meeting. Visitors included E. B. Robertson, Past AIEE President, C. M. Lytle, Past Vice-President, R. F. Danner, Chairman of the National General Committee on Student Branches, and W. C. Fowler, member, Committee on Student Branches

North Texas Section Visits Generating Station

North Texas Section members are shown (left) in the control room of the New Eagle Mountain Generating Station of Texas Electric Service Company, Fort Worth, Texas. The inspection trip took place September 21. (Right) North Texas Section members line up for "chow" before inspecting the generating station

man; K. H. Kidd, Secretary). Activity in this committee centers around two main subcommittees on the Subcommittee on Lightning Protective Devices and the Subcommittee on Fault Limiting Devices.

The one on lightning protective devices is putting the finishing touches on the proposed revision to the Lightning Arrester Standard. This revision eliminates reference to the manufacturers classification of station, line and distribution types of arresters and contains design tests and other data so that the arresters can be catalogued by the design tests which they will meet. After this revision has been approved by the Protective Devices Committee, it will be submitted to the Standards Committee for incorporation in ASA Standard *C-62*.

Working groups have been formed on the following projects sponsored by the Lightning Protective Devices Subcommittee: Surge Protection of Dry Type Transformers, Direct Stroke Protection of Substations, Switching Surge Investigations, Lightning Arrester Application Guide, and Lightning Protection of Aerial Cable.

It is expected that the work of these groups will result in preparation of Transactions papers to be presented at future meetings.

The committee reports covering application guides on ground fault neutralizers, grounding of synchronous generator systems, and neutral grounding of transmission systems have now been published by the AIEE. This is Publication No. *954* and is available from AIEE Headquarters. These reports review basic considerations in applying neutral grounding devices, outline the objectives to be reached and how they can be reached, lists the advantages and disadvantages of each method of grounding and suggests recommendations.

Working groups have been formed on the following projects sponsored by the Fault Limiting Devices Subcommittee: Application of Shunting Arresters on Reactors, Means for Reducing Ground Resistance on Transmission Systems, Revision of AIEE Standard No. 32, and Grounding Practices on Industrial Systems.

There have been some suggestions made that a group be formed to study the ground voltage gradients in substations, also. There is little published information on this subject, and additional work is required.

Committee on Power Generation (*J. B. McClure, Chairman; F. L. Lawton, Vice-Chairman; J. E. Barkle, Jr., Secretary*). A working group of the Excitation Systems Subcommittee continues to develop fundamental definitions pertaining to exciters and generator voltage regulators. The Speed Governing and the Station Design Subcommittees are organizing a joint working group to prepare a report on the control and protection of power stations.

A joint AIEE-American Society of Mechanical Engineers (ASME) Subcommittee on Recommended Specifications for the Speed Governing of Prime Movers has been disbanded. A new subcommittee is being organized under the chairmanship of Wayne Astley. The new subcommittee will cooperate in the formulation of the ASME Test Code and will also revise the existing specifications for speed governing of steam turbines to take into account the newly accepted basis of maximum turbine ratings.

Science and Electronics Division

Committee on Metallic Rectifiers (*Glen Ramsey, Chairman; D. E. Trucksess, Vice-Chairman; E. A. Hart, Secretary*). The Metallic Rectifier Definitions and Test Code were approved and will be submitted to the Standards Committee.

The new Subcommittee on Semi-Conductor Rectifying Devices, under the chairmanship of Dr. S. J. Angello, at a recent meeting outlined the area of endeavor for this Committee. It was decided to cover the little-worked region between semiconductor fundamentals and semiconductor devices.

This area was defined as any subject that relates fundamental semiconductor properties to device characteristics, problems in rectifier applications which can be interpreted on fundamental principles and processes, and methods of manufacture of semiconductor and rectifying devices. It was decided to include circuitry, applications, basic theory or detailed measuring techniques.

The new Subcommittee on Metallic Rectifiers for Magnetic Amplifiers, under the chairmanship of Bruce Seddon, began its activities by outlining its scope. This committee plans to cover all matters regarding the application of metallic rectifiers in magnetic amplifiers including definitions and a test code. Work has begun on definitions that will be needed for this specialized use of metallic rectifier in magnetic amplifier applications.

The chairman, Glen Ramsey, participated in a meeting in Philadelphia of the International Electrotechnical Commission, with representatives of other nations who were interested in metallic rectifiers.

Committee on Basic Sciences (*L. J. Berberich, Chairman; W. R. LePage, Vice-Chairman; S. B. Batdorf, Secretary*). The Basic Sciences Committee and its six subcommittees have been quite active during 1954. This activity was particularly pronounced in the fields of semiconductors, dielectrics, and magnetic materials. The Subcommittees on Applied Mathematics, Basic Concepts, and Circuit Theory have been developing new information in their respective fields through the sponsorship of a number of symposia. This is also true of the Subcommittees on Semiconductors and Transistors, Dielectrics, and Magnetics.

AIEE FELLOWS ELECTED..

Board of Directors Meeting, October 14, 1954

Bell A. Cogbill (AM '38 M '44), development engineer in the advance and development engineering subsection, power transformer department, General Electric Company, Pittsfield, Mass., has been transferred to the grade of Fellow in the AIEE "for contributions to a better understanding of the factors encountered in designing large transformers, and to the advanced technical education of young engineers." Mr. Cogbill was born March 18, 1909, in Marianna, Ark. He obtained his B. S. degree in electrical engineering from the University of Tennessee in 1931, and in 1936 his M. S. He also did graduate work at Ohio State University. From 1931–34 he was instructor at the University of Tennessee, and from 1936–37 was enrolled in General Electric courses. During 1937–39 he designed high-voltage test sets to customers' specifications. Also, he contributed to the design of a novel type of power transformer, the principles of which came into general use about 5 years later. He was a designer of power transformers ranging in kva from 667 to 5,000 during the years 1939–42; was responsible for estimating for quotation purposes characteristics, dimensions, etc., of large power transformers rated 5,000 Kva and above, 1942-43; for design of special power supplies used in connection with the Oak Ridge Atomic Project, from 1943–44; and from 1944–53 for the estimating for quotation purposes characteristics, dimensions, etc., of large power transformers rated 12,500 kva and above. From 1949–51 he gave lectures at the General Electric Company on transformer theory to the advanced engineering class. In 1951 he was instructor of G. E.'s power transformer design class, and from 1952–54 has been instructor of the power systems analysis class for G. E. In 1952 Mr. Cogbill did original design work for a 1,100,000 kva transformer for General Electric's Switchgear Testing Laboratory. This transformer was unusual in many respects and is used for making short circuit tests of high voltage capacitance switchgear. (See AIEE paper, No. *52-190* by Mr. Cogbill entitled, "One Million One Hundred Thousand Kva Short Circuit Transformer in the New High Capacity Switchgear Testing Laboratory," presented at AIEE's Summer General Meeting in Minneapolis, June, 1952, published in the 1953 *Transactions*.) Since September, 1953, he has been an engineer in the advance and development subsection of the Power Transformer Department. He is a consultant on the calculations of reactance, short circuit forces, and other system characteristics particularly on transformers.

B. A. Cogbill

E. F. DeTurk

L. I. Komives

Elmer F. DeTurk (AM '24 M '30) electrical engineer, Long Island Lighting Company, Mineola, N. Y., has been transferred to the grade of Fellow in AIEE "for contributions to design of substations, transmission and distribution facilities for a power system expanding rapidly to meet exceptional load growth." Mr. DeTurk was born in Reading, Pa., October 4, 1899, and attended Lehigh University where he obtained his E. E. degree in 1922. Soon after finishing college, Mr. DeTurk started as a cub engineer in the transmission and distribution department of the Metropolitan Edison Company in Reading. He later organized an engineering division in that department and advanced to superintendent of transmission and distribution. He was in charge of design, construction, and maintenance of the transmission and distribution facilities which comprised overhead and underground lines up to 115 kv for all classes of service. His duties offered excellent opportunity for experience in matters of technical design, construction and operating costs, system performance, field construction and maintenance, right of way, safety accounting, public and industrial relations, sales, employee education, testifying in trials and hearings, and management duties in general. Designs performed by Mr. DeTurk and under his supervision included urban, rural street lighting, railway supply, heavy industrial, commercial, services, etc.; 115-kv steel-tower lines, a "downtown" underground system including a secondary network; a variety of substations; some meter applications; inductive interference studies; electrolysis investigations; radio interference studies; and standardization. From 1940 to the present he has been with the Long Island Lighting Company as electrical engineer, in administrative charge of the electrical engineering department. This department performs design of all major electrical installations for the company, including power plants, transmission, and distribution substations in major category, transmission lines up to 138 kv—both overhead and underground, electrical installations in gas plants, control, relaying, special technical studies, equipment selection and procurement, contract negotiation; responsibility for system planning, standardization, and all matters normally related to the engineering design of major system additions. This has covered a growth from a system load in 1940 of 100 Mw to one in 1954 of 500 Mw. Generation additions cover two 40 Mw, three 100 Mw, and one 150 Mw units. Transmission additions cover many miles of overhead and underground lines up to 138 kv. Substations for supply to subtransmission and to distribution system cover about 750 Mw total capacity. Much original development, and some pioneering has been done under Mr. DeTurk's guidance and supervision in the fields of overhead 69-kv wood pole lines, underground 69-kv and 138-kv cables, outdoor power plant features, system relaying, transformer noise reduction, large cable and capacitor switching and utility radio system development. He has given much of his time to AIEE committees and is a past-chairman of AIEE's Lehigh Valley Section.

Laszlo I. Komives (AM '41 M'43), assistant general superintendent, underground lines department, The Detroit Edison Company, has been transferred to the grade of Fellow in AIEE "for contributions to the development and application of high-voltage transmission cable systems." A native of Arad, Hungary, Mr. Komives attended the University of Budapest and received his M.E. degree in 1920. After graduation he spent a year in a test course and three years as assistant to the factory manager of the Siemens-Schuckert Cable Works, Budapest, Hungary. The following two years he was employed by the Ford Motor Car Company as an engineer in the engineering laboratories. He joined The Detroit Edison Company in 1926 as an engineer in the Cable Practice Division of the electrical system's operating department. On this assignment he developed specifications for complete joints and terminals for underground transmission and distribution cable. In 1930 he transferred to the underground lines department, a construction department, as electrical engineer. He was responsible for initiating and supervising experimental testing work on transmission cable (24 kv to 138 kv) and on joint and terminal equipment. Results of this experimentation were reported in numerous technical papers. About 1935 he became a member of the AIEE Insulated Conductor Committee and was active on many of its Subcommittees. In 1939 he visited Europe and studied the new development of high-voltage transmission cable. This study aided in the selection of high-pressure gas-filled pipe cable for 120-kv service on the Detroit Edison systems. In 1945 he was promoted to superintendent of the Cable Division of the underground lines department where he was responsible for the installation of all cable on the Detroit Edison underground system. During this time he remained active on AIEE's Insulated Conductor Committee, serving as chairman of Subcommittee VII, Cable Supply Systems. In 1949 he was appointed U. S. representative to CIGRE (International Conference on Large Electric High Tension Systems), High Tension Insulated Cables Committee. He has also presented many papers at CIGRE meetings in Paris. In 1953 he was promoted to assistant general superintendent of the underground lines department where he is responsible for construction and maintenance of all underground electric and steam-heating facilities of the company. In 1953 he was appointed chairman of the newly-formed Subcommittee XIII (European Practice) of the AIEE Insulated Conductor Committee. His work as chairman of this Subcommittee has resulted in promoting a close relationship with and has greatly improved the exchange of information between cable engineers of America and abroad. This is evidenced by the presentation of numerous papers and discussions by European engineers before the Institute. Mr. Komives is the author of "Impulse Strength as a Measure of Cable Quality," AIEE *Transactions*, 1941, vol. 60, pp. 929–34; co-author of "One-Hundred Twenty Kv Compression Type Cable" and "One-Hundred Twenty Kv High-Pressure Gas-Filled Cable," AIEE *Transactions*, 1942, vol. 61, pp. 652-57 and pp. 658–65. The second of these papers describes not only the first experimental installation in the U. S. of the European type of pipe compression cable, but also the first experimental installation in the world of the American type of pipe compression cable. The last one records the development leading to the first experimental and commercial installation in the world of high-pressure gas-filled pipe-type cable and the first commercial installation in the U. S. of pipe-type cable under paved city streets.

AIEE PERSONALITIES.....

O. E. Buckley (M '19, F '29), retired president of Bell Telephone Laboratories, Inc., New York, N. Y., has been awarded the Edison Medal for 1954 "for his personal contributions to the science and art which have made possible a transatlantic telephone cable; for wise leadership of a great industrial laboratory; for outstanding services to the Government of his country". The Edison Medal will be presented to Mr. Buckley during the general session at the AIEE Winter General Meeting, February 2, 1955, in New York, N. Y. Mr. Buckley was born in Sloan, Iowa. He graduated in 1909 from Grinnell College in Iowa and received his doctor's degree from Cornell in 1914; and immediately entered the engineering department of Western Electric Company, now Bell Telephone Laboratories, as a research physicist. His technical work in the Laboratories was particularly concerned with high vacuum research, research on magnetic materials, and development of submarine telegraph cables. During World War I, Dr. Buckley held a commission as Major in the Signal Corps, and had charge

O. E. Buckley

courtesy Bachrach

F. E. Brooks

R. D. Bennett

of the research section of that service in Paris. He returned to the Laboratories at the conclusion of the war, and became director of research in 1933, executive vice-president in 1936, and president in 1940. Submarine cables have been a subject of special interest to him. High speed loaded telegraph cable was followed by a deep-sea telephone cable incorporating amplifiers in its structure. A project for a telephone cable of this type to cross the Atlantic Ocean is now under way. During World War II, in addition to his responsibilities as president of the Laboratories, he was active in a number of national projects, including the Communication and Guided Missiles Divisions of the National Defense Research Committee. At the conclusion of the war, he was awarded the Medal for Merit. He has received honorary degrees of doctor of science from Grinnell College and from Columbia University, and the degree of doctor of engineering from Case Institute of Technology. He is a member of the National Academy of Sciences and of the American Philosophical Society; a fellow of the American Academy of Arts and Sciences, and of the American Physical Society. He was a member of the General Advisory Committee of the Atomic Energy Commission 1948–54, is a member and former chairman of the Science Advisory Committee of the Office of Defense Mobilization. He was vice-president of AIEE's District No. 3 (1946–48) and served on the following committees: Electrophysics (1926–37, Chairman 1929–31); Basic Sciences (1946–48); Research (1934, 1937–40); Charles Le Geyt Fortescue Fellowship (1939–42, Chairman 1941–45); Finance (1946–47); Edison Medal (1944–49); Technical Program (1945–47); Meetings and Papers (1929–31); Executive (1946–48); Communication and Science Coordinating Committee (1947–48).

F. E. Brooks (AM '38, F '48), vice-president, operating staff, New York Telephone Company, will retire February 1. He has been with the company 42 years. Following graduation with a B. S. degree in electrical engineering from Case Institute of Technology in 1912, Mr. Brooks entered the company as an engineering assistant in New York City. He was one of the engineers pioneering in the use of dial equipment in the city and also rose to various positions in plant extension engineering. Promoted to the position of chief engineer of the company's Bronx-Westchester area in 1939, Mr. Brooks was made assistant vice-president in 1942, assigned to placement of company personnel in Army and Navy communication assignments during World War II. He subsequently served as chief engineer, first in the Long Island area and then in the Manhattan-Bronx-Westchester area, before becoming assistant vice-president in charge of plant and engineering on the company's operating staff in 1950. During the past three and a half years he has been vice-president in charge of the staff. In World War I, he served two years with the 409th and 412th Telegraph Batallions, which were organized by the Bell System. He held the rank of major, and is at present a colonel in the New York National Guard. He served as communications officer, Westchester County War Council, and on the Technical Advisory Committee, Second Regional Office of Civilian Defense, during World War II. In 1951 and 1952 he was a member of the group under Federal contract (Project East River) to study civil defense.

R. D. Bennett (F '35), technical director, Naval Ordnance Laboratory (NOL), Silver Spring, Md., has become manager, technical department, of the Knolls Atomic Power Laboratory, research facility managed by General Electric Company, in Schenectady, N. Y. Dr. Bennett was ordered to active duty as lieutenant-commander, USNR, in 1940. In 1942 he became commander and directed the Mine Design Section. He served the NOL as captain and technical director, from 1944–47. He has been awarded the Legion of Merit by the U. S. and the decoration of Honorary Officer of the Military Division of the Most Excellent Order of the British Empire. Since July of 1950 he has served as member-at-large of the National Research Council. He is also a member of the Committee on Specialized Personnel of the Office of Defense Mobilization. His other professional memberships include: Sigma Xi, Sigma Pi Sigma, the American Society for Engineering Education, Washington Philosophical Society, American Institute of Physics, and the Institute of Radio Engineers. AIEE Committees he has served are: Standards (1938-46); Marine Transportation (1943–44); Research (1947–51, 1954–55); Management (1948–53); Education (1949–53).

R. K. Honaman, (AM '16, F '36, Member for Life), director of publication of Bell Telephone Laboratories and former mayor of Glen Ridge, N. J., is now serving with the U. S. Department of Commerce in Washington as special consultant and director of the Office of Strategic Information. A native of Lancaster, Pa., he received the B. S. and M. S. degrees from Franklin and Marshall College. In World War I he spent two and a half years with the National Bureau of Standards in Washington, working on studies related to airplane engine design. During this same period he also served as assistant professor of electrical engineering at George Washington University. He began his telephone career in 1919 with the American Telephone and Telegraph Company's development and research department and with that group transferred to Bell Laboratories in 1934. A considerable part of his work during those years dealt with protection of telephone circuits, and he was granted 12 patents for inventions in protection, carrier transmission and allied fields. When, at the beginning of World War II, Bell Laboratories undertook to train technicans for the Army and Navy on radar and related developments, he organized the Laboratories School for War Training, and served as its director until 1945. At the end of the war he was appointed assistant director of publication. He celebrated his thirty-fifth anniversary of service with the Bell System, November 17.

W. L. Cisler (M '35, F '47), president of The Detroit Edison Company, has been elected to the Board of Trustees of the National Sanitation Foundation, Ann Arbor, Mich. Mr. Cisler was employed by Detroit Edison in 1943. He was granted leave of absence to serve in the U. S. Army at the request of the Secretary of War. He returned to Detroit Edison following his military retirement and became chief engineer of power plants. He has many war decorations. For further biographical details see the December issue of Electrical Engineering, p. 1134. Mr. Cisler's committee activities have included: Power Generation (1935–41, Chairman 1940–42, 1943); Technical Program (1940–42); Standards (1941–42); Management (1947–49, Chairman 1948–49, 1950–54); Professional Group Coordinating (1948–49).

Samuel R. Rhodes (AM '12, M '19, F '41, Member for Life), head of the Electrical Department, Clemson College, Clemson, S. C., has retired after 42 years of service in the department, with 25 of these years as its head. He was born in Darlington, S. C. on July 27, 1881, graduated from Furman University of South Carolina in 1900, received his master's degree in 1901, and taught in South Carolina public schools 4 years.

He then attended Clemson College (B. S. degree in mechanical and electrical engineering in 1907, and professional electrical engineer degree in 1928). After two years with General Electric Company and four years as instructor at the University of North Dakota, he returned to Clemson in 1913. Professor Rhodes has been active in the AIEE for 42 years, being co-founder and past chairman of the South Carolina Section. He is a member of the American Society of Engineering Education, the South Carolina Society of Engineering (past-president), and also the honor societies of Tau Beta Pi, Blue Key, and Phi Kappa Phi.

C. F. Prideaux (AM '33, M '44), project engineer, The Austin Company, New York, N. Y., has been named president of a new Brazilian engineering and construction company by The Austin Company. The new firm is the Companhia Austin—Engenheiros e Constructores and will have its headquarters in Sao Paulo. Mr. Prideaux joined The Austin Company as an electrical engineer in the Cleveland district in 1941 after eight years as an electrical superintendent and commercial engineer for public utilities in Minnesota, and two years (1940–41) as electrical engineer for the Panama Canal. He was associated with Austin's vast magnesium plant building program during World War II, serving as assistant to the general project engineer for the units erected at the Diamond Magnesium Company's plant in Painesvilles, Ohio, and for operation by International Minerals and Chemical Company in the Southwest. On completion of this work, he served two years as project manager for the Consolidated Vultee Aircraft Company's plant expansion in San Diego. Since the War, Prideaux has served as project manager on the University of Maryland's large wind tunnel; on a number of public utility distribution warehouses, including the Quebec Hydro-Electric Commission's huge new service center in Montreal; manufacturing plants for the Black and Decker Manufacturing Company and the Link-Belt Company, and a new antibiotics plant in Brazil. Prideaux is a native of Adrian, Minn., and has an electrical engineering degree from the University of Minnesota. Besides AIEE, he is a member of the Illuminating Engineers Society and the National Society of Professional Engineers.

H. W. Collins (AM '22, F '48), general superintendent, Detroit Edison Co.'s electric system since 1945, has been promoted to the position of special assistant to the company's manager of engineering. **D. D. Chase** (AM '29, M '39), assistant superintendent to general superintendent of the electric system, will assume Collins' former duties. **E. W. Spring** (AM '26, M '32), staff assistant, will now be superintendent of electric system equipment, and **H. R. Stevenson**, assistant manager of sales is assistant manager of operations, reporting to the operations manager. Collins has served on the following AIEE committees: Protective Devices (1931–47, Chairman 1946–47); Technical Program (1946–48); Standards (1946–47); Award of Institute Prizes (1946–47); and Power Coordinating (1947–49). Chase has served on the Membership Committee (1947–48), and Stevenson on the Safety Committee (1951–53).

W. D. Bolton, (AM '51) technical engineer, development engineering department, International Business Machines Corporation, (IBM) Endicott, N. Y., has beeen named development engineer in the research engineering department of IBM. He was hired by IBM in July, 1950, as a member of the engineering training program in Endicott, and one year later was assigned as a designer in the physics laboratory. In April, 1951, he was transferred as a designer in research engineering. He became an associate engineer in research engineering in June, 1953, and in January, 1954, was named project engineer.

B. C. West, (AM '39, M '46) sales manager, Pacific Oerlikon of Tacoma, Wash., is now with Federal Pacific Electric Company as apparatus engineer. His headquarters are now in Seattle, Wash.

George Tenney (AM '35, M '42), president of McGraw-Hill Company of California, has been elected vice-president of the International Science Foundation, San Francisco. Mr. Tenney has served on AIEE's Domestic and Commercial Applications Committee (1944–46, 1948–51); and the Publications Committee (1949–53). He is also vice-president of District No. 8 (1953–55).

A. B. Bronwell (AM'34, M'44), professor of electrical engineering at Northwestern University and secretary of the American Society for Engineering Education since 1947, has been appointed president of Worcester Polytechnic Institute, Worcester, Mass. He was born in Chicago, Ill., August 18, 1909. He attended the Illinois Institute of Technology where he received a bachelor of science degree in electrical engineering. In 1936 he obtained a master of science degree from the same institute and did further graduate study at the University of Michigan in 1939 and 1940. He also has a degree in business administration from Northwestern University. After graduation in 1933, Professor Bronwell was associated with Commonwealth Edison Company, Chicago, until 1937 when he was appointed to the faculty of Northwestern. In the summer of 1941 he was employed by Bell Telephone Laboratories, N. Y., as special project engineer. During World War II he supervised radio and radar training at Northwestern University and served as a consultant to various manufacturing companies. He has served as a Student Branch counselor for AIEE from 1938–1940 and was a member of the AIEE Communications Committee (1939–41).

E. W. Engstrom (F '49), vice-president in charge of research, RCA Laboratories Division, Radio Corporation of America, has been elected a member of the board of directors of the corporation. Dr. Engstrom, who became executive vice-president, research and engineering, on June 4, 1954, has broad responsibility for all research and engineering activities of RCA. In addition, he is head of RCA Laboratories and a member of the board of directors of RCA Victor Company, Ltd., Canada. Associated with the electronics industry since his graduation from the University of Minnesota in 1923, Dr. Engstrom joined RCA in 1930. First as an engineer and then as a research administrator, Dr. Engstrom has had a pioneering role in the development of radio, sound motion picture apparatus, the general science of electronics, and both black-and-white and color television. In December, 1945, Dr. Engstrom was elected vice-president in charge of research of the RCA Laboratories Division. Subsequently, he became vice-president in charge of RCA Laboratories, and then executive vice-president, RCA Laboratories Division. A native of Minneapolis, Minn., Dr. Engstrom is the recipient of the University of Minnesota's Outstanding Achievement Award gold medal, the honorary degree of Doctor of Science from New York University, and a silver plaquette from the Royal Swedish Academy of Engineering Research. He is chairman of the Technical Advisory Panel on Electronics, Office of the Secretary of Defense, Washington, D. C., and a member of the AIEE Technical Advisory Committee to the National Bureau of Standards. He is also serving on AIEE's Lamme Medal Committee (1954–57).

K. A. Norton (AM '41, M '48), chief, Radio Propagation Engineering Division, National Bureau of Standards, Boulder, Colo., is the recipient of a Stuart Ballantine Medal of the Franklin Institute, Philadelphia, Pa. He is being honored for "... his contributions over a period of twenty-five years in the field of radio propagation through which our knowledge has been considerably increased by his measurements; our insight broadened by his theoretical work; our engineering calculations made easier by his charts and our broadcasting frequency allocations above 50 mc established more effectively through his guidance." Born in Rockwell City, Iowa, in 1907, Mr. Norton obtained a B. S. degree from the University of Chicago in 1928.

C. F. Terrell (AM '10, F '46, Member for Life), former general manager of the Greek Electrification program of Ebasco Services, Inc., has been decorated with the Cross of the Taxiarches of the Order of Phoenix by His Majesty, King Paul of Greece. The award was in recognition of his work in Greece in helping to stabilize the Greek economy. Mr. Terrell was vice-president of District No. 9 (1946–48) and served on the Production and Application of Light Committee (1946–47).

R. C. Lyons (AM '42), representative to the Air Force, Sperry Gyroscope Company, Great Neck, N. Y., has been named to the new position of assistant manager, Navy Department, in the Federal Department of Sperry. Mr. Lyons has previously worked as engineer for the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., and as inspector for the Minneapolis-Honeywell Regulator Company.

J. R. Riley (AM '23, M '35), fundamental plans engineer, engineering department of the New York Telephone Company, has retired after more than 40 years of service with

New York Telephone Company. He entered the engineering department following graduation in electrical engineering from Drexel Institute of Technology. He held the position of engineer of fundamental plans for the Manhattan-Bronx-Westchester area. He is a licensed professional engineer and a member of the Telephone Pioneers of America. He has been active in AIEE affairs, having served on both the New York Section and the national Membership Committees.

M. M. Boring (AM '52), engineer, technical personnel services department, General Electric Company, has been named consultant on engineering manpower with headquarters in Schenectady, N. Y.; and **C. F. Savage, Jr.** (AM '35, M '43), assistant to the engineering manager, General Electric Company, Lynn, Mass., has been appointed consultant on professional relations with offices in New York. Boring is vice-chairman of the Manpower Committee of Engineers Joint Council, a member of the New York State Selective Service Appeals Board, and a member of the Committee on Specialized Personnel of the Office of Defense Mobilization. He was graduated from the University of Colorado with a degree in electrical engineering in 1916 and was recruited as a student engineer in the G. E. test course that same year. Since 1922 he has engaged in recruiting, training, and placing G. E. student engineers. Savage is a native of Maywood, Ill. He was graduated from Oregon State College in 1928 with a B. S. degree in electrical engineering. He entered the employment of General Electric at Schenectady that same year as a student engineer on radio testing. In April, 1930, he was transferred to the aeronautics and marine engineering department. In January, 1931, he transferred to the meter engineering department at West Lynn Works, Lynn, Mass. In 1939 he was appointed division engineer of the time switch engineering department at the West Lynn Works, and in 1940 was appointed division engineer of the aircraft instrument engineering department. In 1946 he became division engineer of the Aircraft Instrument Division and technical assistant to the manager of engineering. The following year he was named assistant to the manager of engineering and in February, 1953, was named manager of engineering administrative service in the meter and instrument department. Mr. Savage has served on the AIEE Instruments and Measurements Committee (1947–54).

M. S. Coover (AM '16, F '42, Member for Life), head of the electrical engineering Department, Iowa State College, has been appointed associate dean of the Division of Engineering at Iowa State College. The appointment was effective October 1. Coover has headed the electrical engineering department since 1935. A native of Shippensburg, Pa., he was graduated from Rensselaer Polytechnic Institute in 1914 with an electrical engineering degree. His first jobs were in industry, successively with the New York Central Railroad, Montana Power Company and Hutchinson Power and Light Company. During World War I he served with the American Expeditionary Force in Europe. In 1919 he joined the staff of the University of Colorado, rose to rank of professor, and remained there until going to Iowa State in 1935. He has served in engineering capacities on a part-time basis with General Electric Company, the City of Denver, and the Public Service Company of Colorado. During World War II he was director of the Naval Training School, Electrical, established on the Iowa State campus. He has been active in the American Society for Engineering Education, Engineers' Council for Professional Development, and the Iowa Engineering Society of which he is a past-president and a 1938 recipient of its John Dunlap Memorial Award. Coover has taken a prominent part in the American Institute of Electrical Engineers, serving as a director (1940–44); vice-president, District No. 5 (1944–46); and on the following committees: Automatic Stations (1927–29), Sections (1937–41, Chairman 1940–42, 1943–46), Education (1937–47, 1949–54), Research (1937–40), Planning and Coordination (1940–42), Board of Directors (1940–44), Edison Medal (1941, 1943–44, 1946), Publication (1944–46, 1948), Hertz Award (1944–54), Special Committee on District Boundaries (1944–46), Engineers Council for Professional Development (1945–46, 1948–49, 1951–52), Washington Award Commission (1946, 1948). He was liaison representative on standards (1953–54).

R. G. Robbins (AM '46), vice-president, Eastern Division, Hubbard and Company, has been promoted to vice-president and general sales manager of the Pittsburgh and Chicago plants, covering the Eastern and Midwestern territories for Hubbard. Mr. Robbins joined the Hubbard organization in 1923 as an assistant to several department heads. His other positions with the company have been advertising manager, assistant sales manager, and divisional sales manager.

G. M. Kovac (AM '49), vice-president in charge of sales, export, and new developments with W. J. Fitzpatrick Company, has announced the formation of Cog Engineering Products Company, Chicago, of which he is president. The new company will specialize in methods and manufacturing machinery for continuous processing in industry. Mr. Kovac has resigned from the W. J. Fitzpatrick Company to devote full time to Cog Engineering.

Raymond A. Hopkins (M '19, F '43 Member for Life), head electrical engineer, design staff, Tennessee Valley Authority, Knoxville, Tenn., retired October 8, 1954. Mr. Hopkins headed the electrical design of the Authority's hydro- and steam-electric generating stations since 1934. Since 1910 he had specialized in the electrical design of generating stations and heavy industrial plants with Stone and Webster Engineering Corporation in Seattle, Wash.; Fresno, Calif.; and Boston, Mass. A B.S. degree in electrical engineering, as well as an Electrical Engineer degree were received in 1910 and 1913 respectively at the University of Washington (Seattle). His professional activities have included Sigma Xi and Tau Beta Pi. He is professor of electrical engineering at the University of Tennessee, specializing in electrical design of generating stations for graduate students. He has served on AIEE's Electrical Machinery Committee (1944–47), Insulated Conductors (1947–53), and Rotating Machinery (1947–48).

Robert B. Gear (AM '30, M '37), purchasing agent for mechanical equipment, supplies and construction, Commonwealth Edison Company, Chicago, Ill., has been appointed director of purchases in charge of buying and traffic and stores functions, for all electrical and mechanical equipment, materials and supplies. A native of Chicago, Mr. Gear received a Bachelor of Electrical Engineering degree from Cornell University, 1928. He joined Commonwealth Edison that same year and was enrolled in the student training course. He then began work in distribution engineering. He progressed through various assignments to field engineer for generating station installations. From 1941–46 he served in the Corps of Engineers, U. S. Army on Staffs of Second Army, Western Task Force, Allied Force Headquarters, and Headquarters Army Service Forces. Returning to Commonwealth Edison in 1945, he progressed to section engineer, Station Design Division. On establishment of the Nuclear Power Study Group in 1951, he became technical director and later manager. After a short time as staff assistant to the executive vice-president, he was transferred in 1953 to purchasing activities. He has served as director of the Illinois Engineering Council and is currently secretary of the Chicago Section, AIEE.

Bernard L. Friedman (AM '51), assistant to the engineering director, Sanborn Company, Cambridge, Mass., has been elected president and general manager, as well as chief engineer of the newly-formed Photronics Division of the Hauman Instruments Company, Inc. This Division designs and produces electronic-flash equipment for the photographic field, as well as photo-electric control systems.

OBITUARIES

John Boswell Whitehead (AM'00, M'08, F'12, Member for Life), professor emeritus of electrical engineering, Johns Hopkins University, and a Past AIEE President (1933–34), died November 16. Until a recent illness developed, Dr. Whitehead had been doing classified electronics research study for the U. S. Air Force. During World War II he did work for both the Navy and the Air Force. He was born in 1872 and was a graduate of Johns Hopkins University. He obtained his Electrical Engineer degree in 1893, a B.A. in 1898, and a Ph.D. in 1902. He had also traveled extensively through England, France, and Switzerland. He had held various positions including consulting engineer, designer of apparatus, laboratory chief, office executive, research engineer, and teacher, all in the electrical field. Some of the companies he was connected with included: Westinghouse Electric and Manufacturing Company, Niagara Falls Power Company, and the Baltimore and Annapolis

Short Line Railroad. He began as an instructor in the Electrical Engineering Department in 1898 at Johns Hopkins. He later was in charge of the department. Among papers he wrote are: "Inductive Electromotive Force in Transformers," "The Magnetic Effect of Electrical Displacement," "The Measurement of Self Inductance," and "From Steam to Electricity on a Single Track Road." These papers were written between 1900–08. He had been an active AIEE member for many years. He founded the Baltimore Section in 1904 and served as its chairman for 19 years. In 1941 he was awarded the Institute's Edison Medal. Committees he served on follow: Basic Sciences (1911–17, Chairman 1912–16, 1922–28, 1933–36); Meetings and Papers (1912–16, 1923–27); Membership (1915–16); Research (1920–27, Chairman 1922–27, 1933); Education (1922–28); Award of Institute Prizes (1926–27); Electrochemistry and Electrometallurgy (1924–33); National Research Council, Engineering Division, (1925–28, 1935–39); Code of Principles of Professional Conduct (1927–33, 1937–38); Executive (1933–36, Chairman 1933–34); Edison Medal (1933–39); Charles A. Coffin Fellowship and Research Fund (1933–34); John Fritz Medal Board of Award (1933–39); American Engineering Council (1933–34); Institute Policy (1934–38, Chairman 1935–37, 1939–40); Special Committee for Consideration of Broadening of Institute Activities (August–October, 1936); Special Committee on Institute Activities (1936–37).

George Augustus Jessop (M '29), consulting engineer for the S. Morgan Smith Company, York, Pa., died September 24. Mr. Jessop, internationally known hydraulic engineer, started employment with the S. Morgan Smith Company in 1901 learning the machinist trade. In 1909 he received a degree in mechanical engineering from the University of Michigan. In 1923 he became chief engineer for the S. Morgan Smith Company, the position he held until his retirement in 1949. Mr. Jessop was a life member of the American Society of Civil Engineers and chairman of the technical committee of the Hydraulic Turbine Section of the National Electrical Manufacturers Association. He served on AIEE's Power Generation Committee (1929–31).

Irving Henry Osborne (AM '05, M '38), retired chief electrical engineer, Federal Shipbuilding and Dry Dock Company, Kearny, N. J., died at his home in Stony Creek, Conn., September 26, 1954. He was born November 11, 1876, in Waterbury, Conn. Mr. Osborne retired in 1948 from Federal Shipbuilding and Dry Dock Company, with which he was associated since 1919. He was a graduate of Pratt Institute in Brooklyn, N. Y., and was chief draftsman of the Newport News Shipbuilding and Dry Dock Company, New Port News, Va., before joining Federal. He was a life member of AIEE and an active member of the following committees: Marine (1918–43, Chairman 1941–43, 1944–46); Technical Program (1941–43); and Standards (1941–43).

Wesley B. Hall (AM '21, M '28, F '47), professor and head of the Electrical Engineering Department of the University of Rhode Island, died September 7, 1954. Prof. Hall was born in Shelton, Conn., December 22, 1895 and obtained his Bachelor of Philosophy degree in 1916 from Yale University. He received the Electrical Engineering degree in 1921. He served in the Naval Reserve and was commissioned an ensign. He was recalled for active duty during World War II and taught at the U. S. Naval Academy where he held the rank of commander. Since 1936 he was head of the Electrical Engineering Department at the University of Rhode Island. Previously he was on Yale University's faculty. Professor Hall's professional memberships include: American Society for Engineering Education, the Providence Engineering Society, the Yale Engineering Association; and the honorary scholarship societies of Sigma Xi, Tau Beta Pi and Phi Kappa Phi. He was a member of AIEE's General Power Applications Committee (1924–25).

Jose Angel Caparo (M '18, F '32) retired professor of electrical engineering at the University of Notre Dame, died recently. Dr. Caparo was born in Kuzco, Peru, November 2, 1888. He graduated from the University of Notre Dame in 1905 where he received his Bachelor's degree and later his Ph. D. From 1913–17 Dr. Caparo taught physics at Notre Dame and was head of the Electrical Engineering Department there from 1918–39. He continued to teach until 1946 when he retired because of illness. During World War I he taught physics at the Carnegie Institute of Technology. Dr. Caparo was the author of several articles on engineering and was also the author of "Desire for Gold and Conquest," an historical novel about Peru, published in Boston in 1953. Dr. Caparo also did some consulting work in his field. He was a past counselor of the Student Branch at Notre Dame, and was a charter member of the Mathematics Association of America.

Robert L. Grim, student at Michigan State College (East Lansing) was killed in a head-on automobile collision, November 24, 1954. Mr. Grim was chairman of the joint AIEE-IRE Student Branch at Michigan State. He was an outstanding student and under his leadership the Student Branch was having one of its most successful years. His memberships included the Institute of Radio Engineers, Eta Kappa Nu, Tau Beta Pi, and Farm House Fraternity.

MEMBERSHIP • • •

Applications for Election

Applications for admission or reelection to Institute membership, in the grade of Member, have been received from the following candidates, and any member objecting to election should supply a signed statement to the Secretary before January 25, 1955, or March 25, 1955, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Alsberg, D. A., Bell Telephone Laboratories, Inc., Murray Hill, N.J.

Bruce, F. M., The Royal Technical College, Glasgow, Scotland.
Burns, G. M., M. M. Dillon & Co. Ltd., London, Ont., Canada.
Crooks, R. K., Battelle Memorial Institute, Columbus, Ohio.
Duquette, J. F. (re-election), Westinghouse Elec. Corp., East Pittsburgh, Pa.
Edson, R. E., Canadian General Elec. Co., Montreal, Quebec, Canada.
Kobak, E. (re-election), 341 Park Avenue, New York, N. Y.
Shaw, H. S. (re-election), Methodist Road, R.F.D. 1, Westbrook, Maine.
Watson, W. T., Judson Mills, Greenville, S.C.
Zurowski, R. A., S. & C Electric Co., Chicago, Ill.

10 to grade of Member

Recommended for Transfer

The Board of Examiners at its meeting of November 18, 1954, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Member

Adams, C. G., elec. engr., General Electric Co., Schenectady, N.Y.
Anderson, H. L., engr., Dingle Clark Co., Cleveland, Ohio
Barnes, I. M., Jr., project engr., Tennessee Valley Authority, Chattanooga, Tenn.
Baylis, A. H., switchgear product engr., Westinghouse Electric Corp., Detroit, Mich.
Bell, T. J., meter supervisor, Carolina Power & Light Co., Raleigh, N.C.
Bonacker, H. C., operating staff engr., Ohio Bell Telephone Co., Cleveland, Ohio
Cerow, J. A., Jr., vice pres.-engr., Chapman Valve Mfg. Co., Indian Orchard, Mass.
Chang, S. S., assoc. professor, New York University, New York, N.Y.
Conner, G. C., chief, system planning section, Bonneville Power Administration, Portland, Ore.
Culbertson, A. F., manager, transmission engg. dept., Lenkurt Electric Co., Inc., San Carlos, Calif.
Detrick, H. B., transformer designer, General Electric Co., Pittsfield, Mass.
Ellis, T. E., supervisory electronics engr., U.S. Air Force, Griffiss AFB, Rome, N.Y.
Fisher, J. C., head, electromechanical engg., Calidyne Co., Winchester, Mass.
Hart, H. A., owner & chief engr., Industrial Control Panel Co., Chicago, Ill.
Hedding, L. K., section engr., Union Switch & Signal Div., Westinghouse Electric Corp., Pittsburgh, Pa.
Howlett, C. A., development engr., General Electric Co., Danville, Ill.
Jansen, H. B., project mgr., Boese-Hilburn Electric Co., Kansas City, Mo.
King, H. R., elec. engr., water & power dept., City of Los Angeles, Calif.
Kirchmayer, L. K., analytical engr., General Electric Co., Schenectady, N.Y.
Krieger, R. J., head, Melting Research Div., Titanium Metals Corp. of America, Henderson, Nev.
Ladd, G. O., rate engr., Arkansas-Missouri Power Co., Blytheville, Ark.
Long, L. W., assoc. prof., engg. mechanics dept., North Carolina State College, Raleigh, N.C.
Miller, J. W., field engr., RCA Service Co., Tinker AFB, Okla.
Miller, R. L., manufacturing engr., Westinghouse Electric Corp., Greenville, Pa.
Mohr, B. B., elec. engr., Oklahoma Gas & Electric Co., Oklahoma City, Okla.
New, W. R., chief, special studies sec., Tennessee Valley Authority, Chattanooga, Tenn.
Orrick, L. S., senior design engineer, Consolidated Vultee Aircraft, Fort Worth, Tex.
Palmer, J. R., senior engr., Haller, Raymond & Brown, Inc., State College, Pa.
Phillips, J. D., design engr., General Electric Co., Pittsfield, Mass.
Ray, J. H., elec engr., Erie Railroad Co., Cleveland, Ohio
Robinson, F. P., field engr., General Electric Co., Pasco, Wash.
Robinson, P. B., engr., General Electric Co., Lynn, Mass.
Schloth, D. G., asst. chief, inspection & expediting sec., Bonneville Power Administration, Portland, Ore.
Sexauer, P. S., field planning engr., The Detroit Edison Co., Detroit, Mich.
Sledge, R. P., engr., International Harvester Co., Memphis, Tenn.
Tallman, A. M., chief engr., Pioneer Electric, Ltd., Winnipeg, Manitoba, Can.
Turner, F. J., laboratory engineer, General Electric Co., Pittsfield, Mass.
Whillidin, F. W., project engr., National Scientific Labs., Inc., Washington, D.C.
Wilder, W. deE., supt., Power Control Western Div., Niagara Mohawk Power Corp., Buffalo, N.Y.
Wong, H., elec engr., Ebasco Services, Inc., New York, N.Y.

4 to grade of Member

OF CURRENT INTEREST

High-Speed Electronic Computer Built for Navy's Bureau of Ordnance

The smartest electronic "brain" ever built was demonstrated recently by International Business Machines Corporation. No other computer in existence can match its speed and productive capacity in solving vital defense problems, some requiring literally billions of computations. The big computer, called the NORC, for Naval Ordnance Research Calculator, was built for the Navy's Bureau of Ordnance at the Watson Laboratory operated by IBM at Columbia University.

NORC will shortly be moved to the Naval Proving Ground, Dahlgren, Va., where it will be installed in the Computation Laboratory, which already possesses other computing machines. It is expected that this installation will provide one of the most versatile computing facilities in existence.

Operating instructions and problem data are read into the NORC from the ultra high-speed magnetic tape units shown. More than five times faster than the fastest magnetic tape units currently in use, each of eight of these units can read and write more than 70,000 digits a second, a speed equivalent to that of 14,000 typists. In addition to their use for input and output, the tapes also store intermediate results during calculations

Developments that led to production of the NORC began as a research project in 1946 when IBM sought to perfect electronic computing devices that would count accurately at the rate of one million times a second. The results were so impressive that in 1951, the Navy's Bureau of Ordnance, having a growing need for a calculator of greater capacity, contracted with IBM to build these components into an electronic computer of high performance standards.

The need for such a machine was emphasized by the fact that existing giant "brains," despite their fantastic speed, were still too slow to solve within practicable time limits many problems of interest to defense that otherwise would have to be tackled by costly experimental methods. For example, one such puzzler involving many billions of computations is known as the "cavitation" problem. This involves the size and shape of the cavity or envelope of comparatively empty space that forms around an object moving under water. In the case of an underwater weapon, if the cavity were so big that fin and rudder surfaces did not touch the water, control would be lost or impaired and the target possibly missed. If the cavity is small enough so that steering surfaces engage the water, control is maintained.

The mathematics of the "cavitation" problem have been known but the solution was beyond the practical capacity of existing computers. NORC is expected to obtain solutions within practicable time limits.

NORC substantially exceeds its design specifications in speed, carrying out 15,000 complete arithmetic calculations a second. Each of these operations themselves involves several steps—obtaining the specified numbers from input or storage (memory), performing the calculation, placing the decimal point, checking the answer, and storing the result as directed.

Input of the new machine is by magnetic tapes which are loaded from punched cards on separate equipment. The magnetic tape units, of which there are eight, were specially designed and built for NORC, and provide an unprecedented flow of numerical data into the machine. More than five times faster than the fastest magnetic tape units in current use, these tape units bring data into the electronic calculator at the rate of 70,000 decimal digits a second. So effective are these devices that they are used not only for all input and output of the machine, but also for any large-scale storage of intermediate results during the calculation. Numbers stored in the calculator's cathode-ray-tube memory can be recalled from any one of 2,000 locations in 8 microseconds.

This machine performs its arithmetic just as a person does—a digit at a time, but faster: addition and subtraction of 13-digit numbers in 15 microseconds; and multiplication of numbers of similar size in 31 microseconds. In the process of addition and subtraction, a digit is added each millionth of a second, and in multiplication a digit of the product is produced each microsecond—the entire 26-digit product being formed in 26 microseconds of the 31 microsecond multiplying time.

Many novel engineering features are in-

This view of the Naval Ordinance Research Calculator (NORC) shows, in the foreground, one of the two printers used in the installation. In the background is the logical and arithmetical section of the NORC. A single operator, seated at the console, can start and stop the machine and modify the instruction program during calculations

Future Meetings of Other Societies

Institute of Radio Engineers. New York Section Symposium on Design Principles of Transistor Circuits. January 8, 1955, Engineering Societies Building, New York, N. Y.

Radio-Electronics-Television Manufacturers Association. Symposium on Printed Circuits. January 20–21, 1955, University of Pennsylvania, Philadelphia, Pa.

Institute of the Aeronautical Sciences. 23d Annual Meeting and Honor Night Dinner. January 24–28, 1955, Hotel Astor, New York, N. Y.

American Management Association. General Management Conference. January 24–27, 1955, Statler Hotel, Los Angeles, Calif.

American Society of Heating and Ventilating Engineers. 61st Annual Meeting. January 24–28, 1955, Philadelphia, Pa.

University of Florida. Sixth Annual Southeastern Instrumentation Symposium. January 31–February 2, 1955, Gainesville, Fla.

Society of the Plastics Industry, Inc. Tenth Annual Reinforced Plastics Division Conference. February 8–10, 1955, Hotel Statler, Los Angeles, Calif.

Institute of Radio Engineers. 7th Annual Southwestern Conference. February 10–12, 1955, Baker Hotel, Dallas, Tex.

Instrument Society of America. Annual Winter Conference of the New York Section. February 23, 1955, Hotel Statler, New York, N. Y.

corporated in NORC. The printers, which enable the scientists to follow the calculation, are so arranged that calculations continue during printing, and the speed of calculation is reduced less than 3 per cent while the printers are in operation. Provision also is made for automatically using the same set of instructions to perform successive sets of arithmetic operations on a series of numbers, called automatic address modification.

National Bureau of Standards' Laboratories Dedicated in Colorado

President Dwight D. Eisenhower formally dedicated the Boulder (Colorado) Laboratories of the National Bureau of Standards recently. The dedication climaxed a week-long program of scientific conferences and lectures, an open house, and other activities held in connection with the opening of the new laboratories. Also participating in the program were Secretary of Commerce Sinclair Weeks; Dr. Allen V. Astin, Director of the National Bureau of Standards; and Dr. Frederick W. Brown, Director of the Boulder Laboratories.

The ceremony marked the completion and occupancy of the radio laboratory building by the Central Radio Propagation Laboratory, one of the two major NBS activities making up the Boulder Laboratories. The second activity was at the Cryogenic Engineering Laboratory, located at Boulder for over two years, where the first national conference devoted entirely to the engineering phases of low-temperature research was held.

At a banquet for those attending the conferences, held at the University of Colorado, greetings were brought to the Boulder Laboratories by academic leaders of the area: Dr. Ward Darley, president of the University of Colorado; Dr. W. E. Morgan, president of Colorado Agricultural and Mechanical College; Dr. John W. Vanderwilt, president of the Colorado School of Mines; Dr. Chester M. Alter, chancellor of the University of Denver; The Reverend Richard F. Ryan, president of Regis College; and Lieutenant General H. R. Harmon, superintendent of the U. S. Air Force Academy.

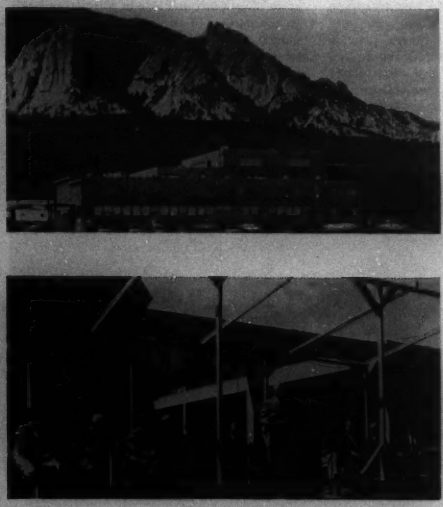
Field trips were conducted to the High Altitude Observatory at Climax for the dedication of the observatory's new solar laboratory and coronagraph; to the Inter-University High Altitude Laboratories at Mt. Evans and Echo Lake under sponsorship of the University of Denver; and to the NBS Cheyenne Mountain Field Station at Colorado Springs.

The Denver section of the Institute of Radio Engineers sponsored a semi-popular lecture, "The Sun and Radio Communications," by Dr. Donald H. Menzel, Director of the Harvard College Observatory.

The new radio laboratory building is a reinforced concrete, wing-type structure featuring a four-story central spine, with one-story wings extending on either side at the second- and third-floor levels. The design takes advantage of a sloping terrain that rises toward the Flatiron Mountains at the west, making all floors accessible from ground level. A number of special features have been included, such as rooms with exact temperature and humidity controls to permit precision experiments, radio-shielded rooms to minimize electrical interference, stable platforms for mounting delicate instruments, an open-roof laboratory for unconfined radio experiments, and access doors for bringing mobile radio test vehicles directly into the building for adjustment and control. The building also has an arrangement by which administrative areas such as the library, auditorium, and main offices can be readily isolated from the laboratory area in case it becomes necessary to impose security restrictions.

The radio laboratory was one of 32 buildings whose architects were voted the Award of Merit by the American Institute of Architects in the Sixth Annual Honor Award Competition for Outstanding American Architecture. The building has been included in a multiple exhibition containing twenty-five of the winning designs, selected on the basis of balanced geographical representation and building types, which will be available for display and study by interested architectural groups throughout the country.

The Cryogenic Engineering Laboratory consists of three principal units: a liquid hydrogen plant, a liquid nitrogen plant, and a group of laboratories for research and development. The major CEL buildings are equipped with safety and anti-explosion devices to minimize the hazards of working with liquid hydrogen in large quantities. The hydrogen liquefying and purifying equipment, which was designed and constructed by NBS, is in duplicate so that the plant can be operated continuously without shutdown. The experimental laboratories have been designed with emphasis on versatility in order to make possible continuing research in a variety of fields of science and engineering as the need arises.



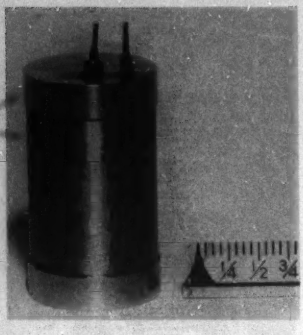
(Top) Air view of the National Bureau of Standards' Boulder (Colorado) Laboratories recently dedicated. (Bottom) President Dwight D. Eisenhower speaking at the dedication of the NBS Boulder (Colorado) Laboratories

Atomic Battery Produces More than One-Half Volt

Scientists have developed an atomic battery which uses the heat from radioactivity to produce electric energy. The new battery makes use of a thermopile (a series of thermocouples) which converts the heat from radioactive decay into electricity. The announcement was made by Dr. J. J. Burbage, director of Mound Laboratory, Miamisburg, Ohio, which is operated by Monsanto Chemical Company for the Atomic Energy Commission.

Using energy given off by decaying atoms as a source of heat, John H. Birden and Kenneth C. Jordan of Mound Laboratory developed a small battery with electric energy comparable to ordinary dry cells. One hundred and fifty curies of the element polonium is sealed in a small capsule, the surface of which is in contact with the hot junctions of 40 thermocouples. The capsule is thermally insulated with a silica aerogel, and is positioned within a surrounding container on the surface of which are located the cold thermocouple junctions. A temperature difference of about 450 F is thus maintained between the capsule and the actual container (or between the hot and cold junctions).

The element polonium is used because it is essentially a pure alpha particle-emitting material. Polonium emits an alpha particle of 5.298-mev energy with a 138-day half-life. At this time, the large scale manufacture of atomic batteries is not economical,



Atomic Battery

as alpha-emitting radioisotopes are routinely available only in relatively small quantities and their cost is high. A battery such as this is believed to have capabilities for use in instruments and apparatus where long life, dependability, and known output are primary requirements. Also, it would be desirable for applications where weight must be limited, and where apparatus is subjected to wide variations in temperature.

Three Long-Distance Centers are Placed in Operation

The Bell System, in the biggest operation of its kind, recently added three new long-distance dialing centers to its network. They are located in White Plains, N. Y., Denver, Colo., and Charlotte, N. C. The new communications centers, along with similar facilities already in operation in 28 other cities, brought the numbers of cities and towns on the nation's long distance dialing network to 3,250.

White Plains and Denver became two of the nine regional centers which serve as crossroad points for express communications in the East and West. The Charlotte system is a sectional center, serving North and South Carolina.

The three new offices are equipped with the latest long-distance "switching" equipment, which automatically routes telephone messages over the most direct channel available. The electronic machinery, known as the "4-A Automatic Switching System," enables the long-distance operator to place a call direct to a subscriber in a distant city without the aid of other operators en route. The equipment selects the best route to the city called, operates switches at intermediate points, tries alternate routes if necessary and completes the connection—all in a few seconds.

More than half of all calls handled at long distance boards are now handled in this manner.

The White Plains system has the capacity to handle up to 50,000 calls per day. The new facilities required for the White Plains project include a coaxial cable between White Plains and Newark, N. J., and another between White Plains and New Haven, Conn. The new office is also tied into Long Lines' nationwide radio relay network through antennas located atop the tower which extends far above the roof of the building.

New Transistor Radio Made Available for Consumer Use

A pocket radio which uses transistors instead of tubes is now in production by Regency of Indianapolis, Ind., a division of Industrial Development Engineering Associates, Inc. It is ahead of the time that was estimated that such a unit could be developed for consumer use. The diminutive radio measures 3 by 5 by $1\frac{1}{2}$ inches, and weighs less than 12 ounces.

The success of the unit is due, in large measure, to a high-performance low-cost transistor developed by Texas Instruments, Incorporated of Dallas. This transistor is known as a grown junction n-p-n type, and its performance is illustrated in the radio wherein power gains of 34 db and 40 db are achieved in the intermediate-frequency and audio stages, respectively. Such figures have previously only been attainable in the laboratory.

The effectiveness of the n-p-n transistors is shown in this set where outstanding performance is obtained through the use of only four transistors in the entire radio, almost half the number hitherto used in laboratory models. The Regency model uses one transistor as a combination mixer-oscillator, two as intermediate-frequency amplifiers, and one as an audio amplifier. A germanium diode is employed as a detector.

Featured in this pocket radio is the advantage of long battery life, because the power consumption is only a fraction of that required for a comparable vacuum tube unit. Since there are no tubes in the pocket radio, the service problem of tube replacement is also eliminated.

Since size and weight are such important factors, most of the design effort was expended in producing the smallest possible package commensurate with the performance standards of other bulkier portable radios. For example, design goal of a speaker was needed that would fit within the space limitations and still perform as effectively as the more voluminous speakers currently used in portable radios. The result was not only a speaker that met these requirements, as produced by Jensen Manufacturing Co. of Chicago, Ill., but one that was more efficient and distortion-free than others of its class.

Television and Motion Picture Cameras Combined

A new motion picture film technique, by which a miniature Du Mont "Tel-Eye" television camera, mounted on a movie camera, gives film directors and their crews instantaneous duplicate television pictures of scenes being shot by the film camera, has been developed by RKO-Pathe and Allen B. Du Mont Laboratories, Inc. It is believed that the technique, which is still in the experimental stage, will have important commercial implications.

Under present movie-making methods, only the cameraman has an instantaneous camera-eye view of the scene being shot when the cameras start to roll. Directors and others vitally concerned in making a movie must wait until the film is developed and the "rushes" screened before knowing how much of the product is usable. Film footage and time are thereby wasted and scenes have to be reshot, all adding to expense and delay.

Under the new method to be demonstrated, the director and his staff can have a large-screen television picture of what the camera sees presented to them at every instant, so that they are in complete control of the shooting at all times. By the use of television units mounted on several film cameras, plus multiple television viewing screens, directors can see at a glance what several cameras "see" and shift from camera to camera as is done in television studios. The end result will be more economical and efficient movie production.

The Du Mont "Tel-Eye" television camera to be used is about the size of a shoe box. It can be mounted directly on a 35-mm movie camera so that its pickup lens "views" the same scene as that encompassed by the film camera lens. The television camera can be plugged into a standard 117-volt a-c wall socket and its output, depending on the type used, may be hooked directly by cable to a standard vhf television receiver or sent through portable accessory equipment to a studio-type viewing screen.

West Virginia Installs Microwave for New Turnpike

Microwave has been installed to provide a modern traffic control and communication system for the multi-million dollar super-

Microwave repeater showing intermediate-frequency amplifier chassis and transmitting klystrons

highway in the Beckley and Raleigh County region of West Virginia.

The new turnpike, one of the most difficult road-building projects ever undertaken, is now partially opened to traffic. It provides a nearly straight through-way over the 88-mile mountainous stretch from Charleston to Princeton, W. Va.

A 3-station 6,600-mc Philco Corporation's microwave system parallels the turnpike. Microwave terminals are located at Bald Knob and Malden Mountain, with a repeater station at Lick Knob. A vhf-radio network, completely integrated with the microwave system, provides communication between police radio cars and control centers along the turnpike.

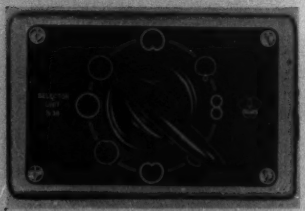
The vhf equipment is installed in 24 mobile units which include police cars, maintenance, and fire-protection vehicles. The microwave system extends the range of the 155-mc vhf equipment. For example, a 30-watt mobile unit operating at one end of the turnpike can broadcast a message which can be picked up by all cars along the 88-mile route. This is accomplished by 60-watt vhf base stations installed at the unattended microwave stations along the turnpike. The mobile units have a choice of two frequencies to use in transmitting. One of these can be used for direct contact with other local mobile units. The other channel provides transmission to the nearest 60-watt base station, which in turn patches the signal into the microwave system to extend the coverage for the entire length of the turnpike.

Microphone Has Remote Controlled Directional Patterns

The *D-36* dynamic microphone, manufactured by Akustische and Kinogeralte Ges. M.B.H., Vienna, Austria, ushers in a new epoch in sound recording technique. The *D-36* has 8 different patterns which may be readily chosen by electrical remote control in contrast to other dynamic microphones which have fixed patterns only.

Using the pattern-control switch box, which may be located several hundred yards from the microphone, the following directional patterns may be selected: 2 cardioids, points of maximum sensitivity opposite each other; 1 omnidirectional pattern; 1 bidirectional pattern; and 4 intermediate patterns, amongst them 2 hyper cardioides.

All patterns have rotational symmetry and may be selected and adjusted during the sound recording without any switching noise. The microphone housing contains two dynamic systems with kidney-shaped directional patterns, arranged in such a way that points of maximum sensitivity are located in opposite directions. The system operates according to a newly patented principle, which is based on the velocity transformation of thin air columns and may be referred to as "nozzle principle." The recording of low frequencies, which are important in music, is made possible to a lower limit of 30 cycles per second, reducing simultaneously the sensitivity to vibration and wind to a great degree. The development of the various directional patterns is obtained by vectorial addition of the kidney characteristics which are volume controlled proportionally.



Pattern-control switch box for the D-36 dynamic microphone

The advent of the *D-36* opens new vistas for sound recording and radio. The role of the sound engineer is enhanced; and gains in meaning due to the revolutionary properties of the *D-36* because intensity and directional patterns may be adjusted to an optimum value, during the recording or while on the air.

Special effects may be obtained by masking certain sound-zones. The effect of an actor approaching and moving away from the microphone may be achieved much more effectively using the pattern control than through the actual movement of the person. When recording plays and with large orchestras, it is possible to attenuate unexpected and unwanted noise from a specific direction by changing the directional pattern. In some instances this may save the recording. Thus it becomes unnecessary to instruct an actor to move away from the microphone in case he comes too close to it, as in an endeavor to have his voice sound soft and intimate.

Electrode Plant Is Opened in Montevalle, Alabama

Modern production techniques characterize the new Westinghouse Electric Corporation plant in Montevalle, Ala., for the manufacture of welding electrodes and brazing rods. The plant will consume over two million pounds of hot-rolled wire per month. It is the first electrode plant in the South, and was built to meet the growing market for electrodes and brazing rods in that section.

The plant has essentially three lines: one for welding electrodes, an adjacent line for compounding flux coatings, and a line for the manufacture of phosphor-copper alloy and phosphor-silver-copper alloy brazing rods. The hot-rolled wire is mechanically descaled, and air-hosed before it goes into a wire-drawing machine where it is then drawn to size.

The wire is cut into lengths of 14 and 18 inches, and is simultaneously straightened by twisting it about the longitudinal axis. Wire-feeding machines push the electrodes through a die, where a uniform coat of flux is extruded onto them. The electrodes are given a statistical concentricity check; the tolerence is 0.002 inch. From there they go to overhead gas-fired drying ovens, one being 250-feet long and the other 450-feet long, which are divided into temperature zones of 50 feet in length. Temperatures vary from 300 to 750 F. Location of ovens overhead has not only permitted full utilization of floor space, but also has allowed maximum dissipation of heat through large ceiling exhaust fans.

At Westinghouse Electric Corporation's electrode plant in Alabama, between 800 and 1,000 electrodes per minute are carried by this conveyor to the baking ovens located overhead

Brazing rod manufacture starts with a copper alloy ingot. This ingot is heated to about 1,200 F prior to being deposited in a 500-ton press for extrusion. Ingots, $2^1/_2$ inches in diameter, are extruded to diameter as small as 3/16 inch in a single pass. The plant also manufactures brazing rings and brazing strip.

Eight-Per-Cent Efficiency Now Obtained by Solar Battery

A one-third increase in the efficiency of the Bell Solar Battery—first successful device to convert the sun's energy directly into useful amounts of electricity—was revealed recently by Bell Telephone Laboratories, Inc.

Bell scientists had achieved a 6-per-cent efficiency in converting sunlight directly into electricity when the battery was first demonstrated 5 months ago, but now have built experimental cells which yield a record 8 per cent efficiency. These efficiencies are comparable to those of steam and gasoline engines.

"Although there is room for improvement," Gerald L. Pearson, one of the co-inventors of the device, said, "this value of 8 per cent is 10 to 15 times better than the best photovoltaic devices available. We are optimistic that in time a 10 or 15 per cent efficiency can be achieved." The maximum theoretical efficiency is estimated to be 22 per cent.

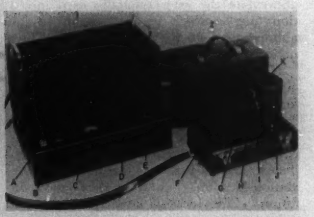
The Bell Solar Battery is an amazingly simple-looking apparatus made of wafers of specially-prepared silicon. One of the world's most abundant elements, silicon is a semiconductor whose particular properties

are especially suitable for converting the sun's energy into electricity. The wafers of silicon are extremely sensitive to light; the improved cells can be electrically linked together to deliver power from the sun at the rate of 80 watts per square yard of surface. The batteries could be used as power supplies for low-power portable equipment, or as sun-powered battery chargers for amplifier stations on telephone lines. Although one watt would not go very far in heating a house or lighting a lamp, it is really quite adequate to power a number of useful communication devices. The battery was invented by a three-member team of Bell Laboratories scientists—Gerald L. Pearson, Calvin S. Fuller, and Daryl M. Chapin, physicist, chemist, and electrical engineer, respectively.

Cuvette Densitometer Measures Cardiac Output

The cuvette densitometer is used in medical practice and research to make a continuous record of the rate of dye dilution in the heart chambers by observing the blood flow from a peripheral artery. From this record, calculations can be made to determine the amount of blood pumped by the heart during each stroke. To the research physiologist, cardiac output is not only an important index of heart function but is also of great interest in studies of the cardio-vascular system. An improved densitometer developed by S. R. Gilford of the National Bureau of Standards (NBS) possesses several advantages over previous instruments of this type. Among these are greater stability and sensitivity, smaller size, and greater convenience of application. The development is part of a program on medical instrumentation carried out at the NBS in cooperation with the Army Medical Service Graduate School.

One of the serious defects in previous instruments for measuring blood opacity has been instability in the electronic circuitry. During the approximately 30 seconds required to record the dye-dilution curve, it is essential that zero and gain be stable. Also, since it is necessary to calibrate the instrument—a procedure which may be delayed by several hours in some instances—it is essential that the sensitivity remain constant for considerable periods of time. In the design of the NBS cuvette densitometer, therefore, very careful consideration was given to obtaining high stability of sensitivity.



Improved cuvette densitometer developed at the National Bureau of Standards. Chassis 1, the electronic unit contains: A, pilot light; B, power switch; C, indicating galvanometer; D, zero suppression control; E, scale-factor switch. Chassis 2, the optical system contains: F, lamp housing; G, light-tight sliding tube; H, cuvette housing; I, cuvette; J, photocell housing; K, neutral-density filter selector

The optical system of the instrument includes a source of monochromatic light for illumination of the cuvette, and a photocell to intercept the transmitted light. A stable light source is obtained by using an incandescent lamp powered by a constant-voltage transformer. A condensing lens collimates the beam of light. The filters which provide the monochromatic light give maximum response to Evan's Blue, an organic dye.

The cuvette brings into the optical path a continuous blood sample about 1.0 millimeter thick. The optical density of the undyed blood averages about 2.0 to monochromatic light centered at 630 millimicrons, and the dye increases this background density by about 0.1. To assure complete interchange of fluid, the cuvette is designed so as to prevent streaming of the blood flow. Thus, the material in the cuvette is representative of the instantaneous concentration of dye and is not influenced by the previous concentration.

The optical system has an additional feature which permits calibrating the equipment independently of the biological system. A series of neutral-density filters are arranged on a cylinder so that they can be readily introduced into the optical path. It is then possible to check the stability in the operating region with a stable input signal, and to plot the linearity of the output function over the operating range.

The NBS densitometer uses a phototube of the multiplier type to provide the required sensitivity. However, when a photo-multiplier tube is used with conventional circuits, it may cause variations in sensitivity and baseline stability. This effect is noticeable even when the output current is very low. In the NBS instrument, the effect of cell fatigue is overcome by using the Sweet circuit, described in the *Journal*, Society of Motion Picture Television Engineers, January 1950, as a feedback system in which the dynode potentials of the phototube are automatically decreased as the light level is increased. The result is that the circuit tends to maintain a constant output current regardless of the light flux impinging on the photo-cathode. Thus, the total current drawn from the anode never exceeds 1 microampere; at this level fatigue is negligible.

In this circuit, the anode current, normally the output, is kept constant and the dynode divider potential, which is a function of the incident flux, is used as the output. However, the output is not a linear function of the incident flux, but rather the logarithm of this quantity. Since the concentration of the dye is directly proportional to the optical density, and since the logarithmic characteristic of the instrument gives the optical density function, the output of the instrument is directly proportional to the dye concentration.

As the optical density function is a directly additive quantity, the relationship between the output and the concentration remains constant. Thus, a given change in concentration of the dye in the blood produces the same change in output regardless of the background optical density. This is not true for a system with linear response, which gives a progressively decreasing output for equal concentration changes as the background density increases. With the logarithmic function that is incorporated into the NBS instrument, the scale factor does not require readjustment for successive dye injections after the initial determination has been made.

Although the Sweet circuit will measure optical density over a range of at least 0 to 3.0, the NBS densitometer requires only a range of 0 to 0.1. The circuit was therefore modified to include a zero suppression system which is initially adjusted to balance out the output resulting from light transmission through the background density of the undyed blood. Thus, the output can be introduced into an amplifier of sufficient gain to give full-scale recording for maximum density change produced by the dye.

With an output recorder having a full-scale response of 50 microamperes, a density change of 0.07, corresponding to a concentration of Evan's Blue dye of 0.007 milligram per cubic centimeter, produces a full-scale deflection in the presence of a background density of 2.5. At the same time, the long-term stability of the baseline is about 10 per cent of full scale per hour. Superimposed on the long-term drift are short-term random variations which are approximately 3 per cent of full scale.

In actual use such sensitivity is not required, since the maximum dye concentrations encountered in the physiological application are in excess of 0.007 milligram per cubic centimeter. In the laboratory, sensitivities about 1/4 of the maximum are used. At these settings, short-term variations are virtually undetectable, and long-term variations present no problem since the determinations are completed in a minute or less.

The components of the NBS cuvette densitometer are divided into two units—the optical assembly in one, and the electronic circuitry in the other. The optical assembly is housed in a small wooden carrying case that can be removed when the instrument is in use. In practice it is usually placed near the patient or experimental animal to be studied. The two fluid connections that must be made are standard fittings that are interchangeable with most couplings on medical equipment. The cuvette is readily removed from the system for cleaning and sterilization. The optical assembly with its photocell is coupled to the electronic unit by 12 ft of cable.

The second unit contains not only the power supplies and the detecting and amplifying circuitry but the controls as well. A gain control, which is kept at one setting throughout the experiment, and a zero suppression control, which the operator manipulates until the indicating meter reads zero, are the only electronic adjustments to be made in the normal use of the instrument.

New Method for Casting Intricate Machine Parts

Up to 500 gears, cams, or small machine parts can be cast at room temperature from Bakelite *C-8* epoxy resins using a gallon of Bakelite vinyl resin-base plastisols to make low-cost flexible molds. The new flexible-mold method developed by Houghton Lab-

Fast and economical method for reproducing intricate machine parts. (Top). Plastisol is poured around a gear, forming a mold 1/4-inch thick. (Center). After the gear is removed from mold, a resin is poured into the cavity and allowed to set. (Bottom). The cast part is easily stripped from the flexible mold without using mold release agents

oratories, Inc., Olean, N. Y., is simple, convenient, and economical for limited production runs, as well as for laboratory development work.

The first step consists of pouring fluid plastisol around the object to be reproduced, and curing it at 350 F for 15 to 20 minutes, depending on the mass of plastisol used. Then the original mold pattern is simply popped out of the flexible mold leaving an accurate mold cavity. The second step is to fill this mold cavity with the cold-setting resin. This formulation gels in 1 to 3 hours and hardens up to 3 hours later at room temperatures. The finished part is then easily popped out of the flexible mold which requires no mold release agent.

Stanford Research Institute to Assemble Information on Hawaii

Stanford Research Institute (SRI) is establishing a project office with resident staff in Honolulu, Hawaii.

Dr. J. E. Hobson, director of SRI, said in announcing the move, "The situation of project work in the Islands is a significant step in fulfilling the Institute's charter objective of serving the economy of western regions, of which Hawaii is an important part."

The initial operating staff will be headed by William E. Hosken, economist and manager of company development research. An initial interest of the new office will be to assemble information about Hawaii to be incorporated in the Western Resources Handbook, a public service activity of the Institute.

SRI is a nonprofit, public service organization whose business is applied research for industry and government. Founded in late 1946 to promote the economic progress of the West, it has a staff of 840 and is now doing contract research at an annual rate in excess of 8 million dollars. SRI has offices in Los Angeles, Calif.; Phoenix, Ariz.; Portland, Ore.; and Washington, D.C. In addition, it has an Air Research Laboratory in Pasadena, Calif., and a supplemental Radio Systems Laboratory in Hollywood, Calif.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

The "Decilog" Again

To the Editor:

The various comments on the decilog,* some published in your letters columns and many others sent directly to me, have proved interesting and valuable. The need for a new logarithmic unit is increasingly confirmed. It is gratifying to see that by and large the name "decilog" meets with favor. As to the abbreviation, "dg" finds a reasonable degree of acceptance, though other suggestions are advanced.

Mr. E. Oosterling and a few others object to the abbreviation dg for decilog because the same abbreviation could signify "decigram." To the best of my knowledge, neither decigram nor dg has heretofore been used to any appreciable extent. The step of ten from the gram is apparently insufficient to justify a separately identified unit. Similarly decisecond has, as far as I am aware, no usage at all and decimeter is used only occasionally in botany. It should be noted also that the use of the same abbreviation to represent two or more different terms is already quite common; witness, for example: kg for kilogram and keg; pt for pint, part, point, and payment; dr for dram and debtor, etc. If the abbreviation dg for decilog is used in proper context, there should be no confusion with any use of dg for decigram.

Mr. R. V. L. Hartley's comments on the wording of the proposed definition for decilog are well taken and should receive appropriate consideration.

Electrical Engineering is to be thanked for devoting space in its columns to this matter, which promises to be of growing importance in engineering circles.

E. I. GREEN (AM'23, F'46)
(Chairman, Subcommittee No. 13)

To the Editor:

In an article entitled "Decibel en Decilog" in the Dutch periodical "De Ingenieur" of August 6, 1952, Mr. R. Vermeulen drew attention to a recommendation* to introduce a unit called "decilog," denoted by the symbol "dg."

As regards this latter, i. e. the use of the abbreviation "dg," we informed Mr. Vermeulen that we objected to it for reasons associated with the standardization of mathematic symbols and units, for which we referred him to, among other things, the "American Standard Abbreviations for Scientific and Engineering Terms, Z 10-1-1941." Mr. Vermeulen advised us, however, to apply directly to you, which we hereby do.

In our opinion it is not recommendable to abbreviate the internationally used indication "log"—which in itself is already an abbreviation—to g, this letter being internationally used to denote grams.

If not accompanied by a dimensional unit, 40 dg stands, under the present instructions, for 40 decigrams.

We must also not forget that it is quite possible that in the future also centilogarithms and millilogarithms will be introduced, and in that case the use of an abbreviation like "mg" would be even more confusing. The idea of centilogarithms and millilogarithms coming into use is not so improbable as it would perhaps seem.

You will, no doubt, know that the R 10 series of preferred numbers, which is strongly recommended for standardization purposes, contains various numbers of which the decilogarithms correspond with the series of natural numbers, the so-called ordinal numbers.

* "The Decilog: A Unit for Logarithmic Measurement," **E. I. Green.** *Electrical Engineering*, vol. 73, July 1954, pp. 597-9.

By interpolation of intermediate values, other series (R 20, R 40, R 80) have been developed from the R 10 series.

Dr. P. G. Voorhoeve and I suggested some time ago to put a stop to the further development of such series and to adopt the R 240 series as a basis for standardization.

On the other hand—and this applies particularly to German standardization at the moment—it is considered to continue the formation of such series on the basis of decilogarithms and consequently to change over to centilogarithms and millilogarithms, the bases of these logarithms thus being $10^{0.1}$, $10^{0.01}$ and $10^{0.001}$, respectively.

Quite apart from the advantages and disadvantages of such series—whose usefulness, as a matter of fact, can only be proved in actual practice—we can only declare that the introduction of decilogarithms is, in our opinion, a perfectly sound idea and that the term "decilog" is a logical and fully justifiable abbreviation.

In consultation with Dr. Voorhoeve, I would suggest, however, to stimulate the use of "dlog" as a further abbreviation and to reject most emphatically the abbreviation "dg."

Finally, in order to avoid any possible misunderstanding with regard to the application of the decilog for denoting dimensional values, i. e. in combination with, e. g. meters, grams, gauss, watts, etc., I would suggest that recommendations be made to create wider understanding of the conception *logarithmic units*. A *log unit* is then an indication—e. g. logmeter, loggram, loggauss, logwatt—by which is to be understood the logarithm of the number of units: meters, grams, gauss and watts, respectively. Accordingly, 4 loggauss (or 40 dloggauss) means that B = 10,000 gauss, and that 4 logg = 10,000 g, etc.

In our opinion this indication method is simpler and clearer than, e. g. 40 dg (gauss) or 4 + log (gauss), as suggested by others.

E. OOSTERLING

(N. V. Philips' Gloeilampenfabriken, Eindhoven, Netherlands)

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

EINSCHWINGVORGÄNGE GEGENKOPPLUNG, STABILITÄT. By Johannes Peters. Springer-Verlag Berlin, Germany, 1954. 181 pages, 10 by 6¾ in., bound. DM 27. Intended for all communications men, this volume provides a modern treatment of the fundamentals of transmission technique and related problems, including television and electro-acoustics, with applications to control engineering. The book deals particularly with transient phenomena, feedback, and stability, and is based on developments of the last decade. A chapter on mechanical-electrical analogues makes the results applicable to other fields of engineering.

FORM IN ENGINEERING DESIGN. By J. Bereford-Evans. Oxford University Press, 114 Fifth Avenue, New York, N. Y., 1954. 96 pages, 8½ by 5½ in., bound. $1.70. A study of techniques by which engineers and draftsmen can give a fine and lasting appearance to their products. Guiding principles, illustrated by examples of designs, are developed to show why certain shapes look better, how to treat large surfaces and details, how to handle difficult and ugly accessories, and how to select appropriate finishes.

INTRODUCTION TO ELLIPTIC FUNCTIONS. By F. Bowman. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1953, 115 pages, 7½ by 5 in., bound. $2.50. A short practical account of the Jacobian elliptic functions, intended for the engineer or physicist who wishes to familiarize himself with their properties. A few brief examples of applications to technical problems are given, and practical guidance is provided on the use of available tables of these functions.

INTRODUCTION TO NUCLEAR ENGINEERING. By Raymond L. Murray. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y., 1954. 418 pages, 8½ by 6 in., bound. $9.35. Intended for the junior or senior engineering student, this textbook surveys the field of atomic energy and discusses some typical engineering problems. It deals with the nuclear reactor, nuclear fuels, handling radioactive materials, instruments for detection and control, and related subjects. In addition, there are chapters on the uses of isotopes, nuclear propulsion, and on electric power plants using nuclear fuel.

INTRODUCTION TO ULTRAHIGH-FREQUENCY RADIO ENGINEERING. By Stephen A. Knight. Sir Isaac Pitman and Sons, Ltd., London, England (distributed in United States by Pitman Publishing Corporation, 2 West 45th Street, New York, N. Y.) 1954. 256 pages, 7½ by 5 in., bound. $4.50. A knowledge of elementary radio systems and general techniques is assumed for the reader of this book which has been written to provide engineers and students with a working knowledge of the subject. Only mathematics of a simple form are used in the discussion of transmission lines, waveguides, cavity resonators, oscillators, and other representative topics in the field.

KRISTALLODEN TECHNIK. By R. Rost. Wilhelm Ernst and Sohn, Berlin, Germany, 1954. 185 pp., 8½ by 6 in., bound. DM 13.50. A concise but comprehensive summary of the published information on transistor technology up to November 1953. There are three main divisions: atomic phenomena involved in rectification and amplification; manufacture and testing of crystal diodes and transistors; applications.

MOLECULAR THEORY OF GASES AND LIQUIDS. By Joseph O. Hirschfelder, Charles F. Curtiss, and R. Byron Bird. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1954. 1,219 pages, 9½ by 6 in., bound. $20. Part 1 surveys equilibrium statistical mechanics as the basis for theoretical development of the equation of state and discusses main applications of the theory. Part 2 covers nonequilibrium statistical mechanics, transport phenomena, and hydrodynamic applications. Part 3 deals with the electromagnetic and quantum mechanical theory of forces between molecules, atoms, ions, and free radicals. The book is intended for students in chemical physics and as a reference work for industrial engineers and others.

TABLES OF INTEGRAL TRANSFORMS, VOLUME I. Compiled by the staff of the Bateman Manuscript Project, California Institute of Technology. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., 1954. 391 pages, 9½ by 6¼ in., bound. $7.50. The first of two volumes giving tables of integrals involving higher transcendental functions, designed for the use of mathematicians, scientists, and engineers. It covers Fourier transforms (sine, cosine, and exponential), Laplace transforms and inverse Laplace transforms, Mellin transforms and inverse Mellin transforms. Each transform has a separate chapter proceeding from general formulas through tabulations of functions of increasing complexity.

SHIPS, MACHINERY, AND MOSSBACKS. By Harold G. Bowen. Princeton University Press, Princeton, N. J., 1954. 397 pages, 8½ by 5½ inches, bound $6. In telling the story of his life, the author records the development for naval use of high-pressure high-temperature steam machinery, diesel engines, radar, fire-control equipment, and other inventions and techniques. The account covers the years from 1905 to 1947 and includes the Admiral's activities in the seizure and operation of industrial plants for the government during World War II.

SYMPOSIUM ON FLUORESCENT X-RAY SPECTROGRAPHIC ANALYSIS. (Special Technical Publication, no. 157) American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., 1954. 68 pages, 9 by 6 inches, paper. $1.75. The six papers included cover basic theory and fundamentals, X-ray intensity and chemical composition, multichannel recording, the examination of metallic materials, and methods of analyzing stainless steels and minerals.

TRANSIENT ANALYSIS OF ALTERNATING-CURRENT MACHINERY. By Waldo V. Lyon. The Technology Press of Massachusetts Institute of Technology and John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1954. 310 pages, 9½ by 6 inches, bound. $7. Fortescue's method of symmetrical components is applied to the determination of transient behavior of polyphase machines, with the analysis based on Kirchhoff differential equations that apply to the machine and connected system. General analyses of typical problems—effects of capacitors and damper windings, use of ladder networks, etc.—are given in detail.

ASTM STANDARDS ON MATERIALS FOR RADIO TUBES AND ELECTRONIC DEVICES AND ELECTRICAL-HEATING, RESISTANCE, AND RELATED ALLOYS. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., 1954. 230 pages, 9 by 6 inches, paper. $2.75. This is a compilation of forty-four standards in their latest form, including new specifications for chromium-iron alloys for sealing to glass, for high-resistivity, low-temperature-coefficient wire, and for other materials. A number of new test methods and recommended practices are also included.

COIL WINDING. By William Querfurth. George Stevens Manufacturing Company, 6022 North Rogers, Chicago 22, Ill., first edition, 1954. 128 pages, 8½ by 5½ inches, bound. $6.50. This manual for technicians, engineers, and designers deals with the construction, application, range, setup, and maintenance of coil winding equipment, and with mechanical considerations necessary for good coil design. Each of the four chapters included covers a basic type of winding: single-layer, multi-layer, universal, and progressive-universal. Alignment charts and gear tables are given in the appendix, and there is a glossary and brief bibliography.

COPPER. The Science and Technology of the Metal, its Alloys and Compounds. (American Chemical Society Monograph, no. 122) By Allison Butts. Reinhold Publishing Corporation, 430 Park Avenue, New York 22, N. Y., 1954. 936 pages, 9½ by 6½ inches, bound. $20.00. All the important phases of the subject of copper as a chemical element and industrial metal are considered. Separate chapters contributed by specialists are devoted to specific aspects of the following fields: occurrence and extractive metallurgy; physical and mechanical metallurgy of copper and its alloys; properties and applications; and other topics in the physics and chemistry of the metal. Most of the chapters have a list of references appended.

DIESEL LOCOMOTIVES. By John Draney. American Technical Society, 848 East 58th Street, Chicago 37, Ill., 1954. 344 pages, 8½ by 5¾ inches, bound. $4.85. Basic information is provided for the training of personnel engaged in building, operating, and servicing diesel-electric locomotives. Fundamentals of engine cycles and of combustion are treated briefly, and separate chapters give details of engine parts and accessories. The latter half of the book discusses electrical fundamentals. Material included is a revision of a 1943 text issued in two parts.

ELECTRICAL TRANSIENTS. By L. A. Ware and G. R. Town. Macmillan Company, 60 Fifth Avenue, New York 11, N. Y., 1954. 222 pages, 8½ by 5¾ inches, bound. $4.75. This textbook, designed for junior and senior students, uses the Laplace transform freely in a quasi-rigorous manner suitable for students with no mathematics beyond differential equations. In the treatment of certain topics, classical methods are also employed. Material covered includes RL, RC, RLC, and vacuum-tube circuits; compound, switching, and transition transients; nonsinusoidal applied emfs; and repeated and discontinuous functions.

ELEKTRISCHE MASCHINEN. Volume III: Die Transformatoren. By Rudolf Richter. Verlag Birkhäuser, Basel, Switzerland, 1954. 321 pages, 9½ by 6½ inches, bound. Sw. Frs. 26.00. This third volume of a comprehensive standard treatise on electrical

machines covers transformers including following subject headings: construction details and service characteristics; special switchgear and voltage regulation magnetization, leakage, and overload phenomena; cooling, heating, and insulation; design details. The present volume is a corrected reprint of the 1932 edition with a brief supplement covering new developments and recent literature.

ELEKTRODYNAMISCHE MESSGERATE. By A. Palm. Verlag G. Braun, Karlsruhe, Germany, 1954. 74 pages, 8⁹/₁₆ by 5⁷/₈ inches, bound. DM 14.20. A brief, systematic presentation of electrodynamic measurements, covering the following subjects: metering principles and the historical development of their application; accuracy and influence factors; wattmeters; voltmeters and ammeters; quotent meters; special types of meters.

ELEKTRONISCHE UND MAGNETISCHE STEUERUNGEN UND REGELUNGEN IN DER ANTRIEBSTECHNIK. Edited by Wissenschaftlichen Ausschuss des Verbandes Deutscher Elektrotechniker. VDE-Verlag, Berlin, Germany, 1953. 122 pages, 9¹/₂ by 7 inches, bound. DM. 6.00. A symposium of seven papers on electronic and magnetic control and regulation of drives. The several papers deal with fundamental principles, with the selection of the proper equipment, and with various applications to machine-tool drives, process machinery, and other mechanical and electrical devices.

HYDRO POWER ENGINEERING. By James J. Doland. Ronald Press Company, 15 East 26th Street New York 10, N. Y., 1954. 209 pages, 9¹/₄ by 6¹/₄ inches, bound. $7.50. This textbook emphasizes the practical approach to the design and preparation of plans for hydro-electric power installations. Taken up in order are fundamentals, practical routine for selecting runners, design of water passages, proper number of units, and the power station and its appurtenances. There are also separate chapters on costs and on combined hydro and steam plants.

INTRODUCTION TO MATHEMATICAL STATISTICS. By Paul G. Hoel. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., second edition, 1954. 331 pages, 9¹/₄ by 6 inches, bound. $5.00. Some of the important topics covered are sampling inspection, design of experiments, testing of statistical hypotheses, analysis of variance, sequential analysis, and nonparametric methods of analysis. A chapter on probability has been added to this edition, changes in the order of presentation place greater emphasis on theory, and a large number of practical problems have been added.

LINEAR TRANSIENT ANALYSIS. Volume I: Lumped-Parameter Two Terminal Networks. By Ernst Weber. John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1954. 348 pages, 9¹/₄ by 6¹/₄ inches, bound. $7.50. This text for a basic graduate course emphasizes comparison of a variety of methods, offering a review of classical and operational methods of analysis, as well as treatment of the Laplace transform and Fourier integral methods. Appendixes review the mathematics needed for the various sections and provide a brief bibliography. A second volume will deal with the transform methods in the treatment of the more difficult network structures.

MILLIMICROSECOND PULSE TECHNIQUES. By Ian A. D. Lewis and Frank H. Wells. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., 1954. 310 pages, 8⁹/₁₆ by 5⁷/₈ inches, bound. $7.50. This monograph deals with the theory and design of electronic circuits and devices for operation in the range in which time intervals between 10^{-6} and 10^{-10} seconds are of interest. It includes a brief theoretical introduction, consideration of basic circuit elements and equipment—transformers, pulse generators, amplifiers, etc.—and details on applications mainly in nuclear physics instrumentation. A list of references is appended.

NOISE. By Aldert van der Ziel. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y., 1954. 450 pages, 8⁹/₁₆ by 5⁷/₈ inches, bound. $10.35. This study of noise problems in electronic apparatus reduces their solution to analysis of simple networks. It covers methods of characterizing and measuring noise, and its sources in tubes and circuits. It considers, also, some of the problems requiring more elaborate mathematical treatment—fluctuating quantities, detector circuits, etc. A final chapter deals with noise in physical measurements.

PAMPHLETS • • • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All quiries should be addressed to the issuers.

Methods of Reasoning. This booklet is an approach to the scientific method. In condensing, popularizing, and clarifying the method, the author has made the technique of problem solving and decision making immediately available to the reader. The work of the logicians, scientists, philosophers, and theologians has been fitted together to create a pattern for answering today's problem solving needs. Starting from the basic throught of what reasoning is, the booklet proceeds through easily assimilated steps covering the concept of the sensed difficulty, techniques of establishing the problem, and how to state the approach and the method of arriving at sound solutions. An important part of the booklet is a five-step review of the basic material which could always be used as a reminder and guide to clear thinking. $1.00. "Methods of Reasoning" is available from the Publications Office, Cleveland Engineering Society, 2136 East 19th Street, Cleveland 15, Ohio.

Progress Through Invention. The magazine carries reprints of talks given at the Invention Exhibit and Conference held at the Cleveland Engineering Society last May. Articles featured are: "Need for Inventions," Joseph H. Gepfert, Reeves Pulley Company; "What's in the Future," Clifford C. Furnas, Cornell Aeronautical Laboratory; "How to Invent—A Creative Guide," Waldemar Ayres, White Sewing Machine Corporation; "Human Side of the Patent Office," Ernest A. Faller, United States Patent Office; "How to Sell Inventions," C. H. Welling, Welling & Woodard, and "Inventing for Profit," Wallace Nichols, H. J. Rand & Associates. $1.00. "Progress Through Invention" may be obtained from the Cleveland Engineering Society, 2136 East 19th Street, Cleveland 15, Ohio.

Westinghouse Lighting Handbook. A new edition of the Westinghouse Lighting Handbook has been announced by the Lamp Division of Westinghouse Electric Corporation. The new version of this reference is subtitled "Light's Diamond Jubilee Issue," and is a thorough revision. It includes recent data, and reflects current practice. Although published by Westinghouse, the Handbook deals generally with the science and practice of lighting. It is not restricted to specific items of equipment. Some features of the handbook are: a wide, folding insert in color of the entire electromagnetic spectrum; a complete array of distribution curves for various light sources and reflectors; up-to-date information on light measurements and maintenance factors; and recommendations for design and application of lighting systems for specific requirements. A full chapter is devoted to interior wiring for lighting. 250 pages. $2.50. Copies can be obtained from any Westinghouse lamp sales office or from the advertising and sales promotion department, Westinghouse Lamp Division, Bloomfield, N. J.

Proceedings of Symposium on Automatic Production of Electronic Equipment. This symposium was sponsored by the Air Force and Stanford Research Institute, last April 19–20, in San Francisco. The proceedings have been published by Stanford Research Institute. The volume contains 17 papers and illustrations relating to the general aspects of automation, product design, construction techniques, materials, components and the design of automatic production lines. A transcript of the symposium's concluding panel discussion is also included, 119 pages. $4.00. The proceedings may be obtained by writing the Public Relations Office, Stanford Research Institute, Stanford, California.

Practical Color Television. The second edition of "Practical Color Television," prepared for use by the television service industry and technical schools, is available from the RCA Service Company. This manual, which contains text, drawings, and photographic explanations of the electronic operations of color television, has been revised and expanded since publication of the original edition. Included are detailed descriptions of a commercial color receiver as well as latest model test equipment for the servicing of color sets. Forty color photographs in the manual were taken directly from the face of a tricolor kinescope tube. Whenever possible, basic color principles are presented in non-technical terms. 80 pages. $2.00. Discount allowed for orders of 12 or more is $1.60 each. "Practical Color Television" may be purchased from the Commercial Service Section of the RCA Service Company, Inc., Camden 2, N. J.

A Survey of Automatic Digital Computers. Operating data on nearly 100 automatic digital computers for general-purpose computation are collected in this report from the Office of Naval Research. General information given for each computer includes builder, location of machine, and whether or not computing time is available. Operational details include number base, word length, instruction type, sequence control, speed and storage type. The report lists both foreign and domestic machines. 115 pages. $2.00. For this report, send to the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. (Commerce Building, Room 6227.) Code Number is PB 111293.

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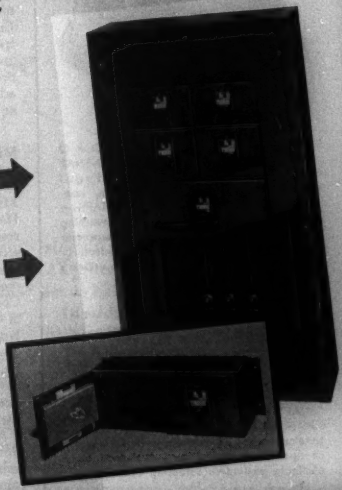

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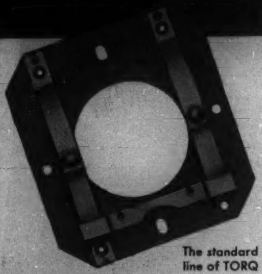

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INDUSTRIAL NOTES ....

NBS Appointments, Retirement. Dr. Michael Danos, formerly a research associate in Columbia University's Radiation Laboratory, has been appointed to the staff of the National Bureau of Standards to conduct work in theoretical physics in connection with the Bureau's betatron-synchrotron program for study of high-energy radiations.

Dr. Ralph J. Slutz, who participated in the design and construction of SEAC, one of the Bureau's electronic digital computers, has been appointed chief of the Radio Propagation Physics Division of the NBS Boulder Laboratories in Colorado. He will direct research on the physics of radio propagation, with particular reference to the ionosphere.

Raymond L. Sanford, assistant chief of the Electricity and Electronics Division and chief of the Magnetic Measurements Section, has retired from the Bureau after more than 44 years of service. Mr. Sanford, who has made many contributions to the field of magnetic measurements, joined the Bureau in 1910.

Johnson Heads RPI Council. Ernest E. Johnson, head of the General Electric Company's general engineering laboratory in Schenectady, N. Y., has accepted the leadership of Rensselaer Polytechnic Institute's Associate Development Council for Engineering. The committee of industrial and business executives which Mr. Johnson heads is engaged in organizing a program for obtaining financial support to advance engineering teaching and research at Rensselaer.

Minneapolis-Honeywell News. A new research and product development center has been opened in Denver, Colo., by Micro Switch, a division of Minneapolis-Honeywell Regulator Company. The new research office becomes the company's second major facility in Denver; the first was opened as a result of Honeywell's recent purchase of the Heiland Research Corporation. Named as general manager of the new Heiland division is Stephen A. Keller, formerly general manager of the company's Valve Division in Philadelphia, Pa. Present general manager of the Valve Division is M. B. Taft, who recently announced the appointment of Ralph A. Rockwell as the Division's chief engineer.

As another indication of Minneapolis-Honeywell's expansion of its research personnel and facilities, the company has retained Dr. Athelstan Spilhaus, dean of the Institute of Technology at the University of Minnesota, as a consultant in the fields of engineering and research.

Lapp Laboratory Dedicated. A new laboratory for research and testing of high-voltage porcelain insulators was opened recently by the Lapp Insulator Company in LeRoy, N. Y. Named in honor of John S. Lapp who founded the company in 1916, the laboratory can handle 60-cycle testing at over one million volts and impulse testing at 2.5 million volts as well as high-current testing.

Sylvania Names Ellefson, Riordan. The appointment of Dr. Bennett S. Ellefson formerly director of research, as technical director of Sylvania Electric Products Inc. has been announced. Dr. Ellefson succeeds E. Finley Carter, formerly vice-president and technical director, who resigned to become head of the research operations at Stanford (Calif.) Research Institute. The company also announced the appointment of Howard E. Riordon as general manager of the Radio and Television Division to succeed John K. McDonough, who resigned recently. Mr. Riordan had been serving as president of Sylvania Electric of Puerto Rico, Inc., a subsidiary manufacturing company.

RCA Announcements. Establishment of a separate semiconductor operations department, devoted to engineering and manufacture of transistors and other semiconductor electron devices, has been announced by the Tube Division of the Radio Corporation of America. The department's headquarters will be at the company's Harrison, N. J., tube plant. Dr. Alan M. Glover has been named manager of the department; Norval H. Green is manager, semiconductor manufacturing; Robert E. Higgs, manager, planning and scheduling; and Dr. Lewis Malter, manager, engineering.

A separate operations staff for administration of all activities connected with the engineering and manufacturing of color television picture tubes at RCA's Lancaster, Pa., plant has been set up. With Harry R. Seelen as manager, the color kinescope operations department will include: Donald O. Corvey, manager, purchasing; S. M. Hartman, manager, equipment development; Homer L. May, manager, planning and controls; C. Price Smith, manager, engineering; and Rex E. McNickle, administrator, quality control. Kenneth M. McLaughlin has been appointed manager of the color kinescope plant.

Other recent appointments include: Douglas Y. Smith as vice-president and general manager, Tube Division; Peter J. Faber to the newly created post of manager, commercial administration—Midwest, Tube Division; Albert F. Watters as vice-president and operations manager of the RCA International Division; and John W. Craig as vice-president and general manager of the RCA Victor Home Appliance Division.

General Electric News. Two new appointments to the staff of the General Electric Company's new Microwave Laboratory in Palo Alto, Calif., have been an-

(*Continued on page 26A*)

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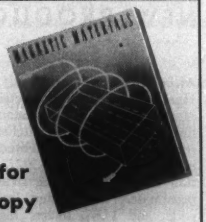

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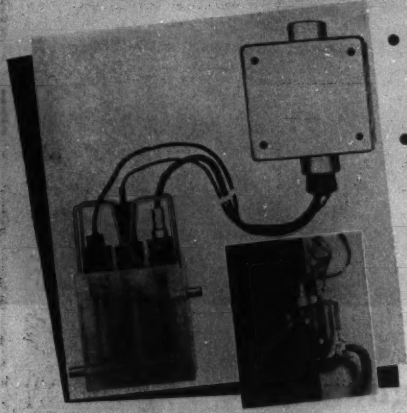

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- RESISTANCE TO ELECTRICAL PICK-UP
- MECHANICAL STRENGTH

The Leeds & Northrup "plastic flow type" electrode assembly above shows the flow block, at left, formulated from HYSOL 6000. Measuring about 4½" by 1½", it has three wells into which the pH electrodes and temperature compensator screw against sealing gaskets. Leadwires from these detecting elements are connected, in the terminal box at top, to leadwires from recording and/or controlling equipment. Insert shows the assembly in operation. The test solution flows through the block, under pressures up to 30 psi, where its pH is continuously detected by the electrodes.

HYSOL 6000 Series epoxide compounds provide the best plastic for this electrode assembly for many reasons. The block itself is produced from a single piece of plastic material. This one-piece construction provides great mechanical strength and prevents solution leakage. The fact that the flow block is chemically resistant is important, since measured solutions are either highly acidic or highly caustic. The d-c electrical insulating properties of HYSOL 6000 Series epoxide compounds minimize electrical pickup and current leakage which would create a measuring error.

Perhaps this use of HYSOL 6000 suggests a possible application for you. The HYSOL 6000 Series includes a complete line of room temperature and heat curing potting and casting compounds, easily machined sheets, rods and tubes and coating and laminating varnishes.

The skilled, experienced experts in our research, design and production departments are ready to serve you. Your inquiries will be answered at no obligation. Put Houghton Laboratories, Inc., products and personnel to work solving your plastic problems. Write, wire or phone today.

PROGRESSIVE PRODUCTS THROUGH CHEMICAL RESEARCH
HYSOL
Product of HOUGHTON LABORATORIES, INC.

houghton laboratories, inc.

105 BUSH STREET, OLEAN, NEW YORK

(*Continued from page 18A*)

nounced. They are James W. Nelson, Jr., as manager for advanced tube development, and George C. Trotter, manager of auxiliary operations. The laboratory is a unit of the laboratories department of the Electronics Division at Syracuse, N. Y.

A new marketing research manager has been named for the radio and television department in Syracuse. He is Lee Schoenfeldt, formerly a distribution analyst with the company's Major Appliances Division at Louisville, Ky. Also appointed recently was Charles M. Young as manager of engineering for the industrial and transmitting tube subdepartment which has its headquarters at Schenectady, N. Y., and operates plants at Syracuse and at Scranton, Pa.

In General Electric's Locke Department in Baltimore, Md., W. L. Turk has been appointed as manager—finance; D. D. Danforth as manager—manufacturing; K. W. Cermak as manager—intra-apparatus group sales; and H. E. DeRoehn as manager—accounting. In Philadelphia, Pa., James R. Bossone has been appointed a district representative to handle construction materials in that area. He previously was in the company's construction service department in Philadelphia, Pa. In California, Harold C. Jenseth has been named manager of the San Francisco plant of the distribution assemblies department. Mr. Jenseth has been with the company since 1945. Another recent appointment is Laurence R. Lee as manager—engineering administration and personnel development in the large steam turbine-generator department at Schenectady.

Walker H. Henry of White Plains, N. Y. senior consultant in the company's manager development consulting service, died recently. A native of Terre Haute, Ind., and a graduate of Rose Polytechnic Institute, Mr. Henry had been with General Electric since 1919.

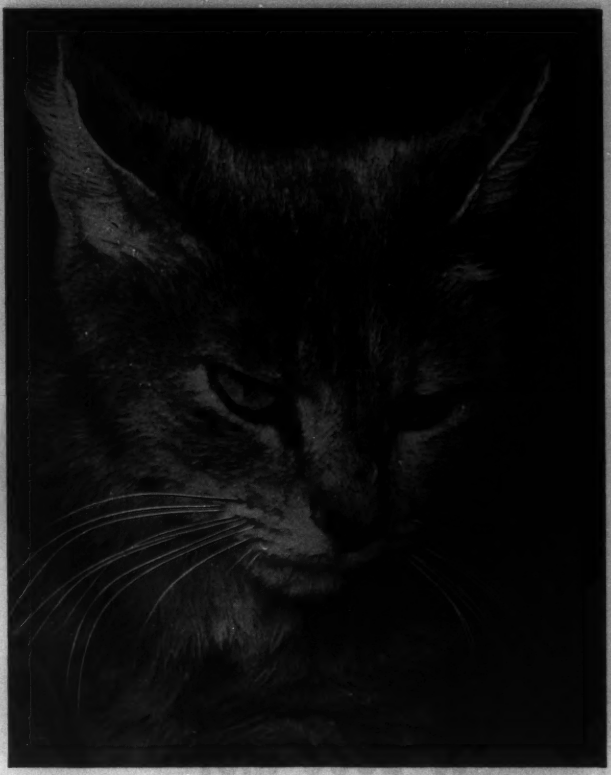
NEW PRODUCTS • •

Aircraft Toggle Switches. The Arrow-Hart and Hegeman Electric Company, Hartford, Conn., has announced a new line of aircraft toggle switches to meet the requirements of Air Force–Navy–Aeronautical Standard *AN-3021*, to Specification *MIL-S-6745*. The switches are approximately $1\frac{1}{8}$ inches long, 5/8 inch wide, and $1\ \frac{9}{64}$ inches high from the bottom of the sleeve to the terminals. The sleeve, which is both sand- and dustproof, is 15/32 inch long Commercial equivalents of the switches, listed as standard by Underwriters' Laboratories, are also available for use as a component by original equipment manufacturers.

Phase Meter. The Phazor Phase Meter Model *200A*, an instrument which permits accurate phase-shift measurements even

(*Continued on page 30A*)

"closer than a cat's whisker"



Cat's whisker standards are not good enough for Armco TRAN-COR DI-MAX coils. That's because nature's thickness tolerances are too high. At the end away from the cat, the whiskers measure about 2-thousandths of an inch thick. At the end approaching the cat they measure about 16 thousandths. In other words, heavy ends.

"Heavy ends" are not limited to cat's whiskers. In electrical steels they can cause trouble because of the wide variation in lamination thickness. There are no heavy ends in Armco TRAN-COR DI-MAX welded coils. The ends are rolled the same as the center.

LONGER DIE LIFE TOO

Armco TRAN-COR DI-MAX is also made to standards "closer than a cat's whisker" to improve die life. Customers report twice the average die life, compared with standard hot-rolled electrical steels. Yet DI-MAX means not only better punching quality but also higher ductility, better flatness and finish.

EXTRA INSULATION IF NEEDED

DI-MAX coils and sheets have adequate insulation for most applications. Where even better interlaminar insulation is required, the steel is supplied with No. 4 Insulation. It withstands annealing temperatures up to 1500 degrees F.

GRADES IN DI-MAX

Armco TRAN-COR DI-MAX, the modernized electrical steel sheet, is available in coils or cut lengths in these hot-rolled, cold-finished grades: M-19, -22, -27, -36 and -43. For complete data write for the new booklet, "Armco Hot-Rolled Electrical Steels."

ARMCO STEEL CORPORATION

4914 CURTIS STREET, MIDDLETOWN, OHIO

ARMCO®

SHEFFIELD STEEL • ARMCO DRAINAGE & METAL PRODUCTS, INC. • THE ARMCO INTERNATIONAL CORPORATION

NOW

Precision Attenuation to 3000 mc!

TURRET ATTENUATOR featuring "PULL-TURN-PUSH" action

SINGLE "IN-THE-LINE" ATTENUATOR PADS and 50 ohm COAXIAL TERMINATION

FREQUENCY RANGE:
dc to 3000 mc.
CHARACTERISTIC IMPEDANCE:
50 ohms
CONNECTORS:
Type "N" Coaxial female fittings each end
AVAILABLE ATTENUATION:
Any value from .1 db to 60 db
VSWR:
<1.2, dc to 3000 mc., for all values from 10 to 60 db
<1.5, dc to 3000 mc., for values from .1 to 9 db
ACCURACY:
±0.5 db
POWER RATING:
One watt sine wave power dissipation

Send for free bulletin entitled "Measurement of RF Attenuation"

•

Inquiries invited concerning pads or turrets with different connector styles

STODDART AIRCRAFT RADIO Co., Inc.

6644-B Santa Monica Blvd., Hollywood 38, California · Hollywood 4-9294

(*Continued from page 26A*)

though the input signal is complicated by noise and harmonic voltages, has been introduced by the Industrial Test Equipment Company, New York, N. Y. The device is useful in the measurement of phase shift in transformers, amplifiers, filter, and phase-displacement networks, and can be employed to measure either in-phase or quadrature voltage components. Power input is 105–125 volts, 60 cps, 25 watts. Dimensions are 9 inches high, 15 inches wide, and 8 inches deep.

Unmounted Motor Speed Controls. Stripped-down models of Variac motor controls for assembly into other equipment will be made available in all sizes from 1/15 to 1½ hp by the General Radio Company, Cambridge, Mass. Variac motor speed controls are versatile general-purpose devices for operating d-c shunt or compound motors from a-c power lines. In the stripped models, all parts except the Variac speed control element are mounted on a metal chassis with connections brought out to a terminal strip. Various circuit arrangements can be used depending on the need for reversing, dynamic braking, etc., but only the Variac and switches need be at the control point.

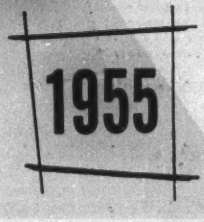
Magnetic Shift Registers. A new line of magnetic shift registers and assemblies, custom-engineered for digital computers, has been announced by the Sprague Electric Company. Single-bit registers are available, with read-in and read-out windings. Also available are combination assemblies which include several register units with parallel or series reading provisions, together with appropriate driving lines for operating frequencies up to 100 kc. Further information is available in Engineering Bulletin No. *550*, obtainable upon letterhead request to the Sprague Electric Company, 321 Marshall Street, North Adams, Mass.

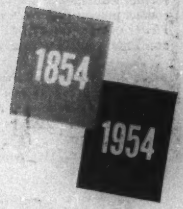
Calibration Pulse Generator. A new calibration pulse generator which facilitates precise measurement of studio color-signal voltage by television broadcast stations has been announced by the Radio Corporation of America, New York, N. Y. It is applicable also for measuring monochrome voltages. The generator (*WA-9A*) provides an output voltage of either 0.5 or 1.0 volt, and holds a steady output signal with rapid changes of as much as 5 volts in the line voltage. The instrument's components are mounted on a compact 5¼-inch chassis, all connections accessible at the rear.

2-Wire Thermocouple. A new 2-wire thermocouple, encased in stainless-steel tubing, has been introduced by the Minneapolis-Honeywell Regulator Company, Minneapolis, Minn. The device is available with either an open-head assembly or a screw-cover head. Accuracy of the thermocouples, which range in length from 6 to 60 inches, is rated at ±5 F over a range from 0 to 1,000 F. Fiberglass insulation permits greater application

(*Continued on page 32A*)

kerite acknowledges





with thanks the good wishes received during
the celebration of our 100th anniversary.
We have been privileged to form many
lasting associations over the past century
and hope to merit their continuance.

Now, on the threshhold of a second century,
we pledge a continuance of the same vigorous pioneering spirit
that produced Kerite insulation and the many
original developments which have protected its integrity
and extended its application.

KERITE CABLE

THE KERITE COMPANY—30 Church St., New York 7, N. Y.
Offices also at 122 S. Michigan Ave., Chicago; 582 Market St., San Francisco;
3901 San Fernando Rd., Glendale 4, Calif.; 31 St. James Ave., Boston

NO. 6 IN A SERIES ON ASSURED POWER CONTINUITY

. . . . Why you must insist on a two position, inherently interlocked, single coil, mechanically locked automatic transfer switch

Properly designed transfer switches must maintain one of two positions:
1. NORMAL CLOSED, EMERGENCY OPEN. 2. NORMAL OPEN, EMERGENCY CLOSED.
Should both circuits be closed, a short circuit from system to system would develop. Should both circuits be open, obviously the load would be disconnected from the power supply.

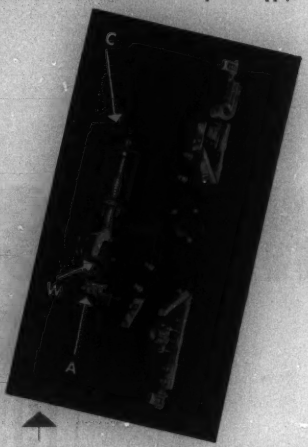
Warning! Any transfer switch providing a possibility of both normal and emergency contacts being open, or both being closed is a source of danger. It can produce the identical condition of power outage which the installation is designed to prevent — with subsequent panic, accident or theft.

ASCO *—designed double throw Automatic Transfer Switches provide only two possible positions—and are inherently interlocked. ASCO Transfer Switches assure power continuity.*

The design simplicity of a single coil — the positive action of mechanical locking offer further assurance of continuous power. High contact pressure minimizes contact I^2R losses. Power outages caused by vibration and other accidental contact openings are eliminated.

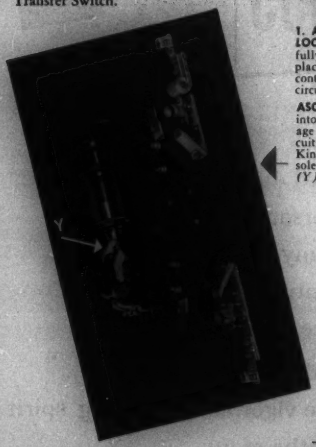
ASCO *Automatic Transfer Switches are of single coil construction and are mechanically locked — two more reasons why ASCO Automatic Transfer Switches assure power continuity.*

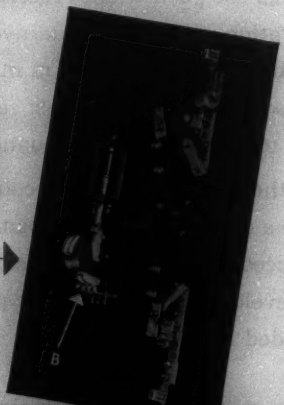
Compare. Then insist on an ASCO Automatic Transfer Switch.



1. ASCO NORMAL POSITION — *MECHANICALLY LOCKED.* Coil (C) de-energized. Compression spring fully extended. Rotating weight (W) at rest. Angular placement of connecting linkages locks weight and main contacts firmly in position. Movable and stationary circuit control contacts (A) are closed.

ASCO CHANGEOVER ACTION — Solenoid core moves into coil compressing spring instantly. Connecting linkage lifts rotating weight, breaking main contacts. Circuit control contacts next open solenoid coil circuit. Kinetic energy continues the motion imparted by initial solenoid pull. *Eccentric cam on weight raises the yoke (Y) which rotates contact shaft.*





2. ASCO EMERGENCY POSITION — *MECHANICALLY LOCKED.* Kinetic energy, accelerated by stored energy in compression spring, moves weight into final position. Movable and stationary contacts (B) are closed. Coil is again de-energized. Angular placement of linkages again locks weight and main contacts firmly. *The return of normal power causes counter operation.*

For more complete information write for the other advertisements in this series—and for Publication 502 which explains how to select Automatic Transfer Switches.

ASCO Solenoid VALVES

Automatic Switch Co.

385E Lakeside Avenue • Orange, New Jersey

ASCO Electric Automatic CONTROLS

(*Continued from page 30A*)

flexibility than is possible with the ceramic-insulated pencil-type models.

5-Kw Induction Heater. A 5-kw induction heater designed for brazing, soldering, and laboratory projects has been announced by the General Electric Company's industrial heating department at Schenectady, N. Y. Effective also for surface hardening and selective annealing applications, the new heater can be simply adjusted to operate at maximum efficiency with a wide variety of inductor coils up to its full rated capacity. It operates electrically as though it were equipped with a continuously variable mechanical transmission, and can be used in many applications that formerly required a heater of 10 kw or larger.

Aircraft Wiring Terminal. A newly developed flag-type, extruded, compression-installed terminal for aircraft wiring is designed for side entrance installations in aircraft where space requirements prevent the use of straight or right-angle-type lugs. Tin-plated copper flag-type terminals (or Hylugs) type *YBM-L* are available for flexible copper cable sizes 8 through 2/0; tin-plated heavy-wall aluminum flag-type Hylugs, type *YBM-A-L* designed to withstand high ambient temperatures and severe overloads, are available for aluminum aircraft cable sizes 8 through 4/0. For further details write the manufacturer, Burndy Engineering Company Inc., Norwalk, Conn.

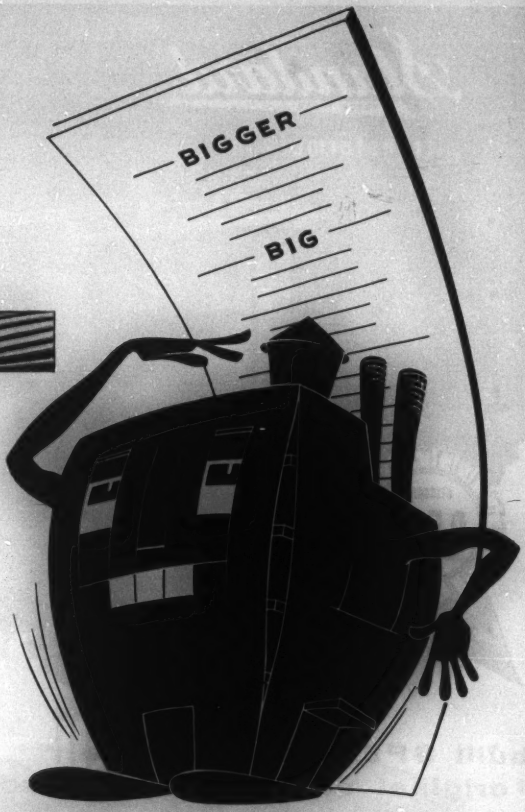
Megger Insulation Tester. Two new models of Megger Insulation Testers are now available in rectifier-operated units: one with a range up to 100,000 megohms at 5,000 volts direct current with 1,000-volts direct current with 1,000-volt and 2,500-volt intermediate ranges, and one with a range up to 200,000 megohms at 10,000 volts with no intermediate voltage ranges. These high ranges are useful in field tests on bushings, generators, transformers, and cables. For complete information on all hand-, motor-, or rectifier-operated high-range Megger Testers, request Bulletin *21-207* from the James G. Biddle Company, 1316 Arch Street Philadelphia 7, Pa.

Proportional Counter. A proportional counter (*WL-6307*) for the detection of thermal neutrons is available from the Westinghouse Electric Corporation. The counter is filled to a pressure of 55 cm of mercury with boron trifluoride enriched to 96 per cent with Boron 10 isotope. The sensitivity of the counter is approximately 4.5 counts per second for a unit thermal neutron flux and it operates in the vicinity of 2,000 volts. For further information, write the Westinghouse Electronic Tube Division, Department T-297, Box 284, Elmira, N. Y.

A-C Control Panels. Jack and Heintz, Inc., Cleveland, Ohio, announces the

(*Continued on page 34A*)

YOUR PLANT
CAN GROW



when you wire
with

ROCKBESTOS AVC®
(N.E.C. TYPE AVA)

WIRE AND CABLE

When you're building your plant, that's the time to install Rockbestos A.V.C. and you will automatically add 30 to 50% more current capacity for future needs.

Get the full story on the practical advantages of Rockbestos A.V.C. — the cable that gives you room to grow.

Phone or write the nearest branch office for a Rockbestos Field Engineer. He's a wire specialist who can save you time and money on your wiring problems.

STOCKED COAST TO COAST

Standard Rockbestos A.V.C. (N.E.C. types AVA, AVB, etc.) are available from stock for immediate shipment. Call or write nearest branch office.

ROCKBESTOS PRODUCTS CORP.
NEW HAVEN 4, CONNECTICUT

NEW YORK • CLEVELAND • DETROIT • CHICAGO
PITTSBURGH • ST. LOUIS • LOS ANGELES • NEW ORLEANS
OAKLAND, CALIFORNIA • SEATTLE

built SPECIALLY for the *original equipment manufacturer

Each component part of **your** equipment must function without failure. One of the most important of these integral parts is the transformer. Standard O.E.M. Transformers are noted for their accuracy, dependability, compactness and sound basic construction. They're engineered especially for O.E.M. use. Many well-known original equipment manufacturers have specified O.E.M. Transformers for over 30 years. You can have Standard O.E.M. Transformers tagged for you, too! Consult your nearby Standard representative or write to Standard direct for specific information, literature or engineering consultation.

Standard
THE STANDARD TRANSFORMER COMPANY

WARREN, OHIO
REPRESENTATIVES IN PRINCIPAL CITIES

(*Continued from page 32A*)

development of new a-c control panels which can be readily "tailored" to the electric system of any aircraft. There are four "basic" panels (that is, they incorporate all the protective and control elements applicable to the particular system): Two panels are for use where direct current is available for control power. One of these is for single-generator systems and the other is for multigenerator systems. The other two basic panels are for operation where direct current is not available for control power. One of these panels is for isolated systems and the other for parallel systems.

Rotating Selenium Rectifier. A rotating selenium rectifier has opened the way towards eliminating the widespread disadvantages of a commutator and slip rings in d-c generators. The basic principle of applying a rotating rectifier is to mount the unit on the same shaft with the alternator field and a-c exciter. Exciter field is fed from an external d-c supply, which may be another rectifier and a variable transformer. Output from the exciter, usually 3-phase, is fed into the a-c terminals of the rectifier. Output from the rectifier is connected directly to the alternator field windings. Using an a-c exciter eliminates the commutator, and since the rotating rectifier is on the same shaft with the alternator field, the usual slip rings are not required. This will eliminate wear and sparking and the resulting r-f interference and brush maintenance. Circuit design data for rotating rectifiers may be obtained by writing to International Rectifier Corporation, 1521 East Grand Avenue, El Segundo, Calif.

TRADE LITERATURE

Powder Core Bulletin. A new Permalloy Powder Core bulletin describing the line of molybdenum permalloy powder cores manufactured by Magnetics, Inc., Butler, Pa., has been published. The bulletin, *PC-103*, describes standard sizes, electrical specifications and tolerances, and types of core finishes. Copies should be requested on company letterhead.

Rubber-Insulated Cable. Bulletin *OK-1085* contains the complete story on Okolite-Okoprene 0- to 5,000-volt unshielded, rubber-insulated neoprene-sheathed cable. The bulletin includes current-carrying capacity tables, short-circuit curves, voltage regulation formulas, and methods for determining conduit sizes, pulling tension, and bending radii. Copies may be obtained from The Okonite Company, Passaic, N. J.

Power Transformers. A 16-page engineering manual for Uptegraff power transformers, Bulletin No. *133*, has been

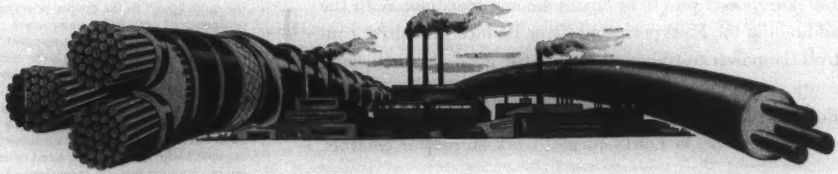
(*Continued on page 52A*)

GENERAL CABLE

THE GREATEST NAME IN ELECTRICAL WIRE AND CABLE

POWER TWINS

...Newest, Most Practical Team for Plant and Equipment Wiring



VARNISHED CAMBRIC OR RUBBER INTERLOCKED ARMORED CABLES

SAFETY m. i. WIRING SYSTEMS

The famous Power Twins combine lower installed costs with unique adaptability. They are ideal for electrical wiring without conduit in close areas and under, down and around beams and pillars...where power needs vary... where plant layout presents difficulties.

Varnished Cambric or Rubber Interlocked Armor Cable is designed for both low and high voltage requirements, (lighting and power control) and is available with steel, bronze or aluminum armor.

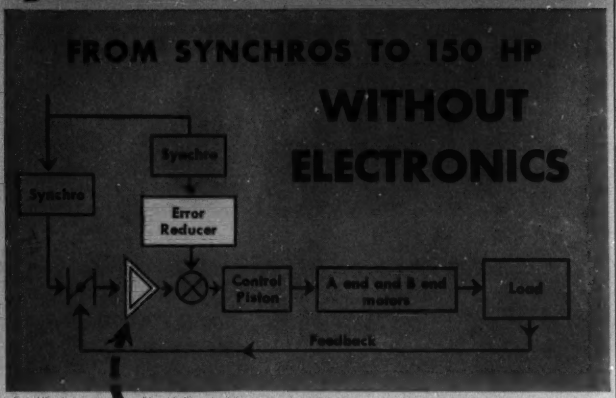
Safety m.i. Wiring System, all mineral insulated and exclusive with General Cable, is ideal for all applications up to 600 v. where heat, vapors, moisture, aging are of particular concern. Lower installed cost! Small diameter saves space! Trains easily for neat, compact installation. Investigate this popular combination before you buy. They can save you time and money.

BARE, WEATHERPROOF, INSULATED WIRES and CABLES FOR EVERY ELECTRICAL PURPOSE

GENERAL CABLE CORPORATION

420 Lexington Avenue, New York 17, N. Y. • Sales Offices: Atlanta • Boston Buffalo • Chicago • Cincinnati • Cleveland • Dallas • Denver • Detroit • Erie (Pa.) Greensboro (N. C.) • Houston • Indianapolis • Kansas City • Los Angeles Memphis • Milwaukee • Minneapolis • New York • Newark (N. J.) • Philadelphia Pittsburgh • Portland (Ore.) • Richmond (Va.) • Rochester (N. Y.) • Rome (N. Y.) St. Louis • San Francisco • Seattle • Syracuse • Tulsa • Washington, D. C.

SINCE 1915 LEADERS IN AUTOMATIC CONTROL



HYDRAULIC
AMPLIFICATION

Ford engineers have developed a highly accurate synchronizing gun drive that is amplified from a small synchro motor to 150 horsepower purely by hydraulic amplification. With the addition of the Ford-perfected Error Reducer, the drive controls the power to train and elevate the guns, thus achieving continuous aiming of the guns with extremely high accuracy. Full use is being made of this experience with hydraulic servo gun drives in Ford's current work on reactor controls.

This hydraulic amplifying system is typical of the unusual amplifying systems developed by Ford Instrument Company over the past forty years. Other examples are the electronic amplifier circuits in mission control computers for the Navy Bureau of Aeronautics, magnetic amplifier circuits for power drives, and transistor amplifiers for missile guidance systems.

If you have a problem in control engineering, Ford Instrument Company's forty years of experience in high precision design and production will help you find the answer. 39

FORD INSTRUMENT COMPANY
DIVISION OF THE SPERRY CORPORATION
31-10 Thomson Avenue, Long Island City 1, N.Y.

ENGINEERS
of unusual abilities can find a future at FORD INSTRUMENT COMPANY. Write for information.

(*Continued from page 34A*)

published by R. E. Uptegraff Manufacturing Company, Scottdale, Pa. The manual provides detailed physical and electrical characteristics for liquid-filled single- and 3-phase transformers from 750 through 10,000 kva. Sections are included on standard accessories, performance data, dimensions and weight, base dimensions, terminal arrangements, and optional accessories.

Aluminum Products and Service. A 24-page booklet containing up-to-date information on Kaiser Aluminum mill products and services is now available from Kaiser Aluminum and Chemical Sales, Inc., Industrial Service Division, 1924 Broadway, Oakland 12, Calif., or from any Kaiser Aluminum sales office or distributor. The booklet contains data on aluminum alloys, forms, properties, applications, and availability. Condensed tables and charts throughout provide convenient reference material.

Tungsten Brochure. Sylvania Electric Products Inc., New York, N. Y., announces the publication of a brochure devoted to the manufacture, properties, and uses of tungsten. Of special interest is the flow-chart which shows how Sylvania tungsten is manufactured and quality-controlled from ore to the finished products. The brochure should be of help in determining the various possible uses of tungsten.

Microwave Equipment. An "engineering guidebook" to the proper selection and arrangement of RCA microwave radio relay equipment for point-to-point communications in applications over distances up to 1,000 miles has been announced by the Radio Corporation of America. The 51-page booklet contains photographs, cutaway drawings, floor plans, and technical data to acquaint communications engineers who are planning fixed or mobile microwave stations, or extensions of existing systems, with the design features and installation flexibility of this equipment. "RCA Microwave Radio Relay Communications Equipment" is available on request from RCA Engineering Products Division, Camden, N. J.

Asbestos Insulations. Johns-Manville has issued three descriptive sample folders to introduce a new series of composite asbestos electrical insulations recently added to the Quinterra and Quinorgo line. The folders contain samples for testing and experimentation plus descriptive information covering application, packaging, physical and electrical properties, and pyrolysis resistance. Folder *EL-54A* covers Quinterra type *3-GR*, a class *H* electrical insulation for operating temperatures up to 250 C. Folder *EL-49A* covers Quinterra type *5-GR* and type *5-GL*, class *B* purified asbestos electrical insulations for temperatures up to 150 C. Folder *EL-55A* covers Quinorgo no. *4000-GR* and no. *4000-GL*, economical class *B* purified insulations. These folders may be secured by writing to Johns-Manville, 22 East 40th Street, New York 16, N. Y.